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MANUAL OF INSTRUCTIONS

FOR THE GUIDANCE OF

ARMY SURGEONS

IN TESTING THE RANGE AND QUALITY OF VISION

OF RECRUITS,

AND IN DISTINGUISHING THE CAUSES OF

DEFECTIVE VISION IN SOLDIERS.

BY

DEPUTY INSPECTOR-GENERAL T. LONGMORE,
PROFESSOR OF MILITARY SURGERY AT THE
ARMY MEDICAL SCHOOL.

ROYAL COLLEGE OF SURGEONS OF ENGLAND

PRESENTED BY THE AUTHOR.

c 1864

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Army Medical School,
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Netley, 2nd October 1863.

SIR,

I HAVE the honour to forward the Manual of Instruction for the optical examination of the condition of vision existing in recruits and others, as well as for the use of the ophthalmoscope in distinguishing deep-seated diseases of eyes, and trust that it may be found to answer the several purposes you proposed when you suggested to me to undertake the composition of such a work.

I have explained at some length in the introductory remarks the plan and objects of the arrangement adopted by me in framing this manual.

I have the honour to be,
Sir,
Your most obedient humble servant,
THOMAS LONGMORE,
Deputy Inspector-General,
Professor of Military Surgery.

Dr. Gibson, C.B.,
Director-General,
Army Medical Department,
London.

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INTRODUCTION.

THIS Manual or Aide-mémoire is compiled with the object of supplying a want which has been the subject of complaint by not a few army medical officers since the introduction of fire-arms with graduated aims. The general use of the rifle in the army has rendered a high degree of visual accuracy on the part of the soldiers for whom these arms are destined a matter of imperious necessity. The quality of eyesight which was good enough to meet the demands of the old smooth-bore musket is by no means sufficient for a weapon which has a range of nearly a thousand yards, and which, to be of service, demands that the soldier who uses it shall have a clear perception, and shall correctly judge the distance, of any object of the size of a man at any position up to that extent of range. It becomes the duty of the medical officer to determine whether the power of eyesight in a recruit is adequate to meet the new demand thus made upon this function by the combatant officer. The determination of the question is readily arrived at if the vision be normal, or if it be abnormal to an extreme extent; but there are many intermediate degrees of defect, and many peculiar complications, which require no little nice discrimination and accuracy of observation in practice to distinguish and define. These difficulties become increased when there is either an unwillingness to assist the surgeon, or positive attempts to deceive him, on the part of the person under examination. It is hoped that the materials in the following pages may be useful in saving time and showing the means of obviating errors in this branch of duty.

But it is not only with recruits that the medical officer has to deal in determining power of eyesight. Soldiers already in the service are frequently declared by musketry instructors to be incompetent for practice with the rifle on account of their inability to see the target at the necessary ranges. The medical officer has then to decide whether the defect complained of really exists or not; whether it is of a kind that admits of remedy; or, whether, being irremediable, the man should be invalided and discharged from further service. Important issues, involving pecuniary and other considerations, depend upon the decision he may arrive at. A soldier who is really the subject of serious disease, may by chance be regarded as a malingerer, because all the superficial ocular apparatus are free from disease, and all that can be seen by ordinary observation of the deeper structures of the eye are observed to act precisely as they do in eyes that are known to be healthy. We have, unfortunately, conclusive proofs that such errors as these formerly occurred very frequently; and that they led to soldiers being sent on foreign service, often to tropical climates, where their diseases became rapidly aggravated, so that they had shortly to be invalided home again, as well as to the retention for considerable periods at home stations of others who were useless, and who had at last to be discharged from the service after much expense being incurred by their prolonged maintenance. If a defect of vision really exist, the medical officer should be able to report to his professional superiors the exact cause of the disability, for on this also may hinge many points of importance to the public service, to the soldier, and to the state. If the defective vision be the result of some natural abnormality of the refractive media or special form of the globe, the service has suffered from the admission into its ranks of an ineligible recruit. If the defect be the result of disease, such as too often follows service under the glare of a tropical sun, then the soldier has suffered from his employment by the state, and is entitled to compensation according to the degree of his disability.

There is only one way in which a diagnosis in these cases can be truly arrived at, and that is by means of the Ophthalmoscope. The important discovery of this instrument has opened up an entirely new field of observation and study, the value of which, as Mr. Bowman has observed, can only now be estimated by trying to suppose what would be thought of an instrument which would enable us to "see the membranes, the cavities, the course of the "fibres, the configuration of the ganglionic masses of the brain, "with the vessels pulsating, the veins varying in emptiness or "repletion, and every product and physical condition of disease "exposed to view,"* or of another, which would, in like manner, expose to our observation the contents of the chest. The ophthalmoscope, however, is comparatively so new, and such difficulties exist in procuring concise guides for its use, especially for the requirements of military service, that, at the request of the Director-General, I have arranged the memoranda contained in this manual in the hope they may meet the want referred to.

A case containing the necessary means for ascertaining the condition of vision, whether normal or defective, and of diagnosing ophthalmoscopically the causes of defective vision when dependent upon disease, has been sanctioned for issue to medical officers, and an explanation of the contents of the case is one of the objects contemplated by the publication of this manual. The remarks in the following pages for observing the different conditions of vision alluded to have, for the most part, reference to the means placed at the command of medical officers by the contents of this case of instruments.

In the volume of the Army Medical Reports for 1860, I published some observations on the examination of the visual fitness of recruits for military service, with special reference to instruction in the use of the rifle. In these notes sets of types numbered in accordance with those assorted for universal reference by Professor Jäger of Vienna, and sets of dots corresponding in sizes with Jäger's test-types for those who could not read, were recommended for testing power of vision. Since that paper was written, Professor Snellen of Utrecht has published a regular series of types of fixed dimensions, and possessing certain definite relations one type with another. They present several advantages over Jäger's types for military use, particularly for meeting cases where it is supposed that deception is attempted; on the one hand, to make it appear that the sight is strong enough for a soldier, on the other to prove the existence of a defect for the purpose of escaping from military service. On this account I have recommended their issue for the use of army surgeons, and the Right Hon. the Secretary of State for War has been pleased to sanction the expense incurred by their distribution. Dr. Snellen's preface to his collection of optometric test-types explains the principles on which they have been designed, and the manner in which they are employed; I need not, therefore, refer at greater length to the subject here.

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* Address by W. Bowman, F.R.S., read at the thirtieth annual meeting of the British Medical Association.

I have divided this *aide-mémoire,* for convenience of reference, into two parts. In the first part I have attempted to explain shortly the nature and distinguishing features of the several kinds of defective vision which the army surgeon is liable to meet in the recruiting room. The second part is devoted to an explanation of the use of the ophthalmoscope, and its application in the diagnosis of disease. Knowing the difficulties under which many army medical officers on active employ, and in remote stations, are placed for reference to scientific and certain professional works, I have thought it advisable to insert some of the laws of light affecting vision, and other collateral matters necessary to be remembered, in order that the practice of the visual examinations described may be conducted with more ease and precision. I have so frequently found explanations asked for on the subjects thus introduced by those who have been studying the practical use of the ophthalmoscope at the Army Medical School, that, although such memoranda may at first appear to some persons out of place, I cannot help believing that they will be found generally useful.

In conclusion, I would beg to urge that this book is only intended to be what I have called it, — an aid to memory. To become expert in the use of the ophthalmoscope, or to speak with authority upon observations made by it, not only must the surgeon make himself practically acquainted with it by a long period of assiduous manipulation, but, if he desire to be scientifically acquainted with the subject of his explorations, he must study the writings of those ophthalmologists who have gained European celebrity by their researches. If he be acquainted with the German language, he will find in the writings of Von Graefe, Professor Donders of Utrecht, and Dr. Liebreich, to all of whom modern ophthalmology is so deeply indebted, profound elucidations of the nature of the diseases which the ophthalmoscope has brought into light. I would especially recommend to the notice of the student the lifelike drawings in that wonder of scientific art, the

"Atlas der Ophthalmoscopie," by Dr. R. Liebreich, Berlin, 1863.* In our own language he will find the "Practical Treatise of "Mr. Hulke on the Use of the Ophthalmoscope," Dr. G. Rainy's "Theory of the Ophthalmoscope," the works of Mr. Soelberg Wells on "Impaired Vision," and of Mr. Jabez Hogg on "Oph-"thalmoscopic Surgery," with the Lectures of Mr. Bowman, of the greatest assistance in following out more deeply the subjects treated upon in this mémoire. I would also especially suggest perusal of the Report by Dr. Frank, in the "Army Medical "Reports" which have been supplied to medical officers for the year 1860, "On the Invaliding from Eye Diseases," not only on account of the exceedingly valuable information contained in that article, but also because it affords the best evidence of the importance of attention to this subject in military practice.

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* I have not applied for the addition of coloured illustrations to this manual for two reasons. The first is the great expense attending them; the second, the difficulty of procuring faithful representations of the coloured appearances presented to the observer by the ophthalmoscope. Pictures of the fundus of the eye are calculated to mislead, when painted by an artist who is not himself an ophthalmoscopist, and the student will, more surely become familiar with the real objects rather by personal exploration, assisted by ordinary instruction, than by the direction of such erring guides. The drawings in the Atlas above referred to are by Dr. Liebreich himself, who is not only an accurate draughtsman, but who also took the trouble to make himself acquainted with the art of chromo-lithography, in order to depict more accurately the objects in their natural colours.

THE

ARMY MEDICAL OFFICER'S OPHTHALMIC MANUAL,

&c. &c.

PART THE FIRST.

OPTICAL EXAMINATION OF THE EYE.

CHAPTER I.

Definition of Perfect Vision.—Radiation.—Transmission of Light.—Law of Visible Direction.—Inversion of Images on the Retina.—Visual Angle.—The Point of Intersection.—Field of Vision.—Position, apparent Size, and true Size of Objects in the Field of Vision.—Definition of the Terms "*Infinite*" and "*Finite*" Rays.—Accommodatory Power of the Eye.—Range of Accommodation.—Nature of Lenses.—Description of the Lenses supplied in the approved Pattern Optical and Ophthalmoscopic Case issued to Army Medical Officers.—Prisms for Ophthalmic Purposes.

Perfect Vision exists when, firstly, the eye is so constructed that an exact picture of surrounding objects is formed upon the retina; and when, secondly, a correct appreciation of the forms, positions, colours, and most of the physical qualities of the objects so depicted is conveyed to the mind. To effect the first of these conditions, the curvatures and refractive qualities of the transparent media must be of such strength, and so combined, that the rays of light proceeding from the external objects are all brought to their proper foci upon the retina; that there is no spherical or chromatic aberration. To effect the second, or the act of sensation, the optic nerve, and its expansion into the retina, must be healthy, and the perceptive faculties must have been duly educated. The study of the faculty of vision, or the means by which the luminous impressions on the retina are converted into the act of seeing, belongs to the province of Physiology.

The properties of light, and formation of images, constitute a branch of physical science, the pursuit of which appertains to the natural philosopher; but some of the principles of optics are so essential to be borne in mind in order to understand the phenomena of abnormal, as well as of normal, conditions of vision, that I propose to recall these, in a concise form, to recollection. I will also, in this preliminary chapter, briefly explain certain expressions in frequent use in connexion with the subject of visual examination.

Radiation.—The expression *ray of light* indicates the straight line along which light is transmitted, and the term *radiation* signifies the transmission of rays in all directions from a luminous point. A collection of rays so disseminated from a luminous point as to assume a conical outline, is called a diverging *pencil of rays;* and the apex of the cone from which they proceed, is called the *focus* of the pencil. So also, when rays are caused to converge to a common point, they are together spoken of as a converging pencil of rays; and the point at which they all meet is called the focus.

The illuminated surface of any object, in respect to the light it is receiving, is regarded as lighted by the bases of a number of pencils of rays, whose foci are at the source of illumination; and, in respect to the light it is imparting by reflection from its surface, by means of which it is rendered visible, it is regarded as composed of an infinite number of luminous points, which points are the foci of a corresponding number of pencils of rays. It is important, when speaking of the rays proceeding from an illuminated object, not to confound the rays emanating from two points remote from each other (as from the extreme points between which the visual angle is included, for example,) with the rays proceeding from each luminous point of the object independently.

Transmission of Light.—Rays of light proceed in straight lines so long as the medium through which they are travelling is of uniform density; but on passing from a rarer into a denser medium they are bent or *refracted towards* a line drawn perpendicularly to the surface of this medium; and conversely, on passing from a denser into a rarer medium, are *refracted from* a line drawn perpendicularly to its surface.

Law of Visible Direction.—Each point of an object is seen in a line perpendicular to the point of the retina which its image impinges. Whatever, therefore, may be the *real* place of an object, if the rays of light proceeding from it are brought indirectly by *reflection*, or by any other means, to the retina, it will not appear to the eye to be placed where it really is, but in a situation perpendicularly opposite to that part of the retina on which its reflected rays have fallen.

Inversion of Images on the Retina.—The mind does not judge of the positions of objects, whether primary or reflected, according to the part of the retina on which their images happen to fall; if it did, the positions of things would appear to change with changes in the position of the eyes looking at them. But the mind judges of the positions of objects by the direction in which the rays of light come from them to the eyes. Hence, though the images of objects looked at directly are inverted on the retina by the action of the refracting media of the eye, the mind, following the lines of light to their true sources in obedience to the law of visible direction, sees them in their real positions and relations to each other. This equally applies to the reflected images of real objects: the reflected images are inverted on the retina, but they are seen truly in the forms in which they proceed from the reflecting medium.

Visual Angle.—The visual angle is the angle included between two rays proceeding from the extreme points of an object to the centre of the eye. These rays meet and cross each other within the eye as they proceed to form the image on the retina.

The point at which they meet is known as "the point of intersection." The size of the visual angle is similar on each side of the point of intersection—towards the object, and towards the retina. The expression that an object occupies so many degrees in the circumference of a circle of which the eye is the centre, or that it subtends an angle of so many degrees, has the same significance as the expression "size of visual angle."

Field of Vision.—The term "field of vision" signifies the whole of the open space which is visible in one position of the eye.

Objects on the Visual Field.—The space and place of objects on the field of vision are measured by the visual angle. The *apparent size* of an object is estimated by the size of the visual angle alone. To estimate the *true size*, the distance of the object, as well as the size of the visual angle, must be known. Conversely, the *true size* of an object being known, the visual angle enables us to form a judgment of the distance at which it is placed from us.

Infinite Rays.—This term, in reference to vision, is employed to express rays of light proceeding from an object in parallel lines, or rather in lines which are so nearly parallel that their divergency is inappreciable; and the expression "*infinity*" is used to signify the distance from which such rays come to the eye. The rays proceeding from luminous points on any object distant from about three feet from the spectator up to that of the most distant star, for all practical purposes impinge on the eye parallel with each other, and are spoken of as *infinite rays.* The divergency of a pencil of rays from a luminous object at a distance of three feet from the eye (supposing the diameter of the pupil to be one-eighth of an inch) would only amount to fifteen minutes of a degree. Rays from objects nearer than three feet are sometimes spoken of as *finite rays.* The divergency of these rays increases in proportion to their proximity to the eye.

Accommodatory Power of the Eye is the faculty which exists in every normal eye of adapting itself almost unconsciously to seeing objects at different distances; or, in other words, of bringing equally to a focus upon the retina rays which are parallel and rays of varying degrees of divergency.

This power of accommodation, which in ordinary optical instruments is effected by altering the mechanical adjustments subordinate to the lenses, in the eye is due to change in the form of the crystalline lens itself. The anterior surface of the lens is rendered more convex for the observation of near objects; its convexity is lessened again for observing objects a little farther off, and for objects beyond a distance of twenty feet, from which rays proceed in nearly parallel lines, it nearly resumes the form which belongs to its state of repose.

The changes in the form of the lens are effected by the *tensor choroideæ* muscle. The iris has been totally absent; all the external ophthalmic muscles have been paralyzed; and yet accommodatory power has remained perfect. Therefore this faculty could not have been dependent on the influence of these structures as was formerly supposed. Moreover, that the lens does become more convex when the eye is observing near objects has been demonstrated by Professor Hemholtz by means of his ophthalmometer.

When an object midway between the two eyes, and at a short distance in front of them, is looked at, the two internal recti muscles act concurrently with the ciliary muscles, and the accommodatory power is thus increased.

The Range of Accommodation signifies the range between the nearest and the most distant points of distinct vision. It frequently is a matter of importance to determine the exact extent of this range in ophthalmic examinations, and the following formula has been put forth by Professor Donders as a general expression for it:—

$$\frac{1}{p} - \frac{1}{r} = \frac{1}{a} \text{ and } \frac{1}{a} = A$$

In this formula p represents the proximate or nearest point of distinct vision: r the remote or most distant point: and a represents the focal distance of a lens which, being placed before the crystalline lens, would cause rays, emanating from the near point, to assume a direction as if they came directly from the far point. A represents the range of accommodation.

Accommodatory Exertion increases in proportion to the proximity of objects, or, in other words, to the divergency of the rays which have to be brought to a focus.

Symbols.—The following symbols are found useful as abbreviations for the expression of measurements:—$1'$, one foot; $1''$, one inch; $1'''$., one line; ∞, infinity.

Lenses.—Lenses are solid transparent media, as glass, bounded by a spherical surface on one or both sides, and having the properties of changing the direction of parallel rays of light, so as to cause them either to converge to a given point—the principal focus; or to diverge as if they proceeded from the principal focus.

The lenses which are chiefly used in correcting abnormal conditions of the refractive media of the eye, and which are employed for ophthalmoscopic purposes, are double convex lenses, having two convex surfaces of equal degrees of sphericity, and double concave lenses, having two concave surfaces, also of equal curvature.

In the combined optical and ophthalmoscopic case, supplied to officers of the Army Medical Department, there are two pairs of spectacles, one pair being furnished with convex, the other with concave, lenses. Each spherical surface, as well in the concave as in the convex lenses, forms part of a circle whose radius is six inches in length. The principal focus is in both cases, therefore, at six inches distance. But parallel rays falling on the convex lenses are made to *converge* to foci at six inches distance from their centres; while parallel rays falling on the concave lenses are made to *diverge* to exactly the same extent as the rays would, if they were proceeding from a point at the same distance from its centre as its principal focus is,—viz., six inches.

If the rays falling on the double convex lines are divergent instead of parallel rays, they will be brought to a focus farther off than six inches; if they are convergent, they will be brought to a focus nearer to the lens than six inches.

If the rays falling on the double concave lens are divergent instead of parallel rays, they will be rendered proportionably more divergent, just as if they came from a point nearer to the lens than its principal focus. If they are convergent, and they converge in a direction towards any point between the lens and its principal focus, the refracted rays will be convergent also; if they converge to a point at the distance of the principal focus, they will be refracted as parallel rays; if they converge towards some point beyond the distance of the principal focus, the refracted rays will be proportionably divergent, just as if they were proceeding from some point further off from the lens than the distance of its principal focus.

These general principles are applicable to all lenses, whatever their focal distances may be.

It is convenient in calculating the forms and focal distances of lenses required for correcting abnormal conditions of the refractive media of the eye, to use the expression + (positive focus) for convexity, and — (negative focus) for concavity.

Prisms.—Prisms of different powers are used in certain parts of ophthalmic practice, especially in the enquiries preliminary to operative interference for the cure of *strabismus* and *diplopia.* Such prisms essentially consist of a solid piece of glass contained between five plane surfaces, of which three are rectangular and the two ends triangular, these latter being at right angles with the base of the prism, and therefore parallel with each other. In order to adapt them for use in front of the eye, however, the angles are sometimes rounded off, and a shape thus given to them which is nearly circular. When a ray of light is made to fall upon one of the sides of this prism, and to pass through it, the ray is refracted towards its base, and the degree of deflection varies according to the size of the angle enclosed between the sides through which the refracted light passes. Taking advantage of these facts, the rays from a given object may be made to impinge upon any part of either retina, by the use of prisms of different degrees of strength; and by these means the presence or absence of binocular vision (both eyes seeing at the same time) may be determined in doubtful cases, diplopia may be counteracted and single vision restored, or the relative strength of the several motor muscles of the eyes be tested.

CHAPTER II.

Vision according to Varieties of Focal Adjustment.—1. EMMETROPIA.—Definition.—Limits as regards Accommodatory Power.—Nearest and farthest Points of distinct Vision.—Visual Limits in respect to Size.—Diagnosis.—2. MYOPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Degree of Myopia and its proper correcting Lens.—3. HYPERMETROPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Degree of Hypermetropia and its proper correcting Lens.—ASTIGMATISMUS.

Other defective States of Vision.—PRESBYOPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—To determine the Degree of Presbyopia and its proper correcting Lens.—AMBLYOPIA.—Definition.—Causes.—Symptoms and Diagnosis.—HEMERALOPIA.—NYCTALOPIA.—HEMIOPIA.—ASTHENOPIA.—Causes.—Symptoms.—Motor Asthenopia.—Accommodatory Asthenopia.—STRABISMUS.—DIPLOPIA.—ACHROMATOPSIA.

As the chief object of this part of the aide-mémoire is to furnish medical officers with such memoranda as will assist them in determining with accuracy the *quality of vision* in any case submitted to their decision, it is necessary first to describe the various kinds of vision he may be liable to meet with. I propose, therefore, in this chapter, to define the chief characteristics of the various conditions of sight depending upon variations in the conformation of the eye, its refractive power, accommodatory power, and upon certain deep-seated diseased conditions, the nature of which can only be detected by ophthalmoscopic examination. It is not intended to refer to changes in strength or quality of vision dependent upon those diseases or injuries which are capable of being seen by the unaided eye of the surgeon. These are properly treated of in systematic works on ophthalmic surgery.

Chief Varieties of Focal Adjustment.—Measure of distance being the chief feature of those conditions of vision which depend upon focal adjustment, all varieties in this respect may be registered under three heads or natural divisions; and the following (among numerous terms which have been employed to express these three divisions or their consequences) appear the most simple and appropriate. These are: 1. Emmetropia, vision in measure, or normal-sightedness; 2. Hypo-metropia, vision under measure, short-sightedness; 3. Hyper-metropia, vision beyond measnre, or over-sightedness. But the classical term—myopia, derived from the habit of short-sighted persons partially closing their eyelids, is so familiarly known, and convenient for avoiding mistakes from similarity in sound between the Greek derivatives signifying under, and over, that it is perhaps best to continue to use it.

Astigmatism is a variety of disordered focal adjustment of a compound nature, the chief features of which, when considered separately, are subjective to one or other of the three leading divisions just described.

EMMETROPIA.

Definition.—Normal-sightedness. When perfect images of external objects at all ordinarily visible distances are formed upon the retina.

Optical causes.—See the definition of perfect vision in previous chapter.

Nearest point of distinct vision.—Although, as already explained, the eye is gifted with accommodatory power, so as to adapt itself for bringing rays of different degrees of divergency to a focus upon the retina, the construction of the eye fixes a limit to this function. In the emmetropic eye this limit is at about 4″ from the cornea. Various circumstances, such as the habit of accommodating the eye to very near objects in certain occupations, modify the limits of accommodatory power to the extent of two or three inches. A near point of 7″ distance is not regarded as a pathological condition.

Farthest point of distinct vision.—Infinite distance. However great the distance of an object so long as the other conditions necessary for perfect vision, viz., sufficient size and illumination are preserved, a perfect retinal image will be formed of it by the emmetropic eye. As already explained, the pencil of rays proceeding from the luminous points of all objects distant more than about three feet from the observer are understood to move in parallel lines.

Dimensions of object necessary for distinct perception.— An emmetropic eye can perceive a plain object occupying only the 60th of a degree, or one minute, in fair daylight. This space, in a circle of 12 inches diameter, of which the eye is supposed to be the centre, is about the 600th of an inch of its circumference. At a distance of six inches therefore the eye can perceive the presence of an object the 600th of an inch in size. An object which subtends an angle of only half a minute, though directly illuminated by the sun, is barely visible. Colour has its influence: it has even been affirmed that a white disc with the light of the sun shining upon it may be seen under an angle of one-fifth part of a minute, or 12 seconds, while, under the same circumstances, a red disc could only be seen under an angle of twenty-three seconds.

But though an uniform object, such as a disc, or "bull's-eye," can be seen by the eye though only occupying a space of the 60th of a degree, it is found that the smallest visual angle permitting clear *recognition* of such broken and irregularly formed objects as printed letters is one-twelfth of a degree, or five minutes. It is on this basis that Dr. Snellen has arranged his test-types. They are each formed of lines one-fifth part of the size of the letter in thickness: therefore, in seeing a line of one of these letters, the eye is really seeing an uniform object which only occupies one minute, while the whole letter is occupying five minutes, in the visual field.

Diagnosis is effected (1) by types, and (2) by spectacles.

1. *By Types.*—The emmetropic eye can read Snellen's types at any of the indicated distances.

2. *By Spectacles.*—The emmetropic eye can read any of the small types at a distance of six inches from the eye when the convex 6″ spectacles are worn. This tests for power of accommodating infinite rays.

MYOPIA.

Definition.—Syn: Hypo-metropia. Short-sightedness. Near-sightedness. Converging power of the eye greater than normal: so that parallel rays are brought to a focus short of the retina. Only divergent rays are focussed upon the retina.

Optical causes.—To produce a myopic condition of vision, either the refracting qualities of the transparent media must be increased beyond due proportion, or the optic axis must be longer than normal, or both may be combined.

Remote causes.—These may be congenital conformation of the eye, and this cause is often hereditary, myopia being frequently seen to prevail in all the members of a family; continued over-exertion at near objects, under which circumstances the capsule of the lens probably loses some of its subjectiveness to change of form, or, from being so constantly accommodated for a very near point, the accommodatory apparatus ceases to be able to relax itself sufficiently for bringing parallel rays to a focus upon the retina; or lastly, diseased conditions inducing increased density of the refracting media, or causing elongation of the eyeball, as *e. g.* Sclerotico-choroiditis posterior, conical cornea, &c. Certain neurotics, as the extract of the Calabar bean, by exciting contraction of the ciliary muscle and constrictor pupillæ, temporarily changes an emmetropic into a myopic eye.

Symptoms.—In uncomplicated myopia very near objects are seen clearly, but more distant objects are misty, surrounded by a halo, and indistinct. Small objects at distances at which normal eyes can see them plainly, the 3 feet black centre of the target at 1,000 yards, for example, cannot be seen at all by a myopic eye, if the degree of myopia be severe. The reason that small objects when held near to the eye are seen distinctly by a myopic person without the use of a lens is that the pencils of rays proceeding from them are by these means rendered divergent; so much so that, the increased divergency being proportionate to the excessive convergent quality of the eye, they are brought to a focus upon the retina, and a proper image is then formed. Hence, no doubt, the origin of the vulgar name of the affection near-sightedness. The reason why objects more distant appear "blurred," or surrounded by a halo, is that after the rays proceeding from them have been brought to a focus short of the retina, they again proceed to diverge, and a certain proportion of these falling upon the retina, surround the picture formed before it. These scattered rays are called "Circles of Dispersion." The farther a given object is removed from the eye the greater will be the increase in the circles of dispersion. The habit which myopic persons have of partially closing their eyelids when looking intently at any object, is an instinctive endeavour to prevent some of the peripheral rays of light reaching the eye, and so lessening the circles of dispersion upon the retina. Perhaps also at the same time the elongation of the eye-ball may be slightly lessened by means of the pressure then exerted upon it.

Myopia, if severe, is not unfrequently found to be associated with Strabismus. The squint is occasionally, but rarely, convergent, in cases where the internal recti muscles have become disproportionately developed, or do not admit of being relaxed in proportion to the external muscles, from constant use, owing to the approximation of objects for distinct vision, but is much more frequently found to be divergent. This prevalence of divergent squint with myopia is thus explained. As the myopic condition leads the patient to bring small objects near to the face to be seen clearly, so a strain is thrown upon the internal recti muscles, and as these get fatigued, they cease to act in true concert, and confused, or double vision, is liable to result. In this case one eye will turn outwards, so as to bring a less sensitive peripheral portion of the retina in line with the object, or, in other words, to make its image as indistinct as possible, so that the production of a mental impression by it may be avoided with more ease. The strabismus may be only temporary in its nature, occurring when near objects are fixedly regarded, or it may be rendered permanent by continued repetition of the circumstances just explained.

Diagnosis is established (1) by external signs, (2) by types, (3) by spectacles, (4) by the ophthalmoscope, and (5) by correction

1. *External Signs.*—The myopic eye usually presents a peculiar appearance indicative of its condition. It is prominent, or even appears to protrude; the pupil is usually contracted, and the constant nipping together of the lids leaves a noticeable impression. The existence of strabismus, as already explained, is a further diagnostic sign of myopia.

2. *By Types.*—The myopic eye cannot form retinal images of objects subtending so small an angle as $\frac{1}{12}$th of a degree, and therefore cannot see Snellen's types at the distances indicated by the figures placed above them. They will have to be brought nearer in proportion to the degree of myopia.

3. *By the Spectacles.*—When the convex spectacles are worn, small type cannot be read at a distance of six inches, but may be read at some point short of that distance. When the concave spectacles are worn, the myopic person, if the myopia be aggravated, can also read at some distance within six inches: if the myopia were to be as severe as $\frac{1}{6}$th, then with these spectacles distant objects with parallel radiation would be rendered distinctly visible.

4. *By the Ophthalmoscope.*—(See Part II., p. 52.)

5. *By Correction.*—When the true degree of myopia is ascertained, the proper concave lenses for that degree will *completely* correct the abnormal condition.

To determine the Degree of Myopia, and its proper correcting Lens, and at the same time the degree of divergent power in a lens necessary to correct the over-convergent action of the eye, is an easy proceeding; for all that is wanted, is to ascertain the greatest distance at which the myopic eye can bring to a focus upon the retina the pencil of rays from small objects without a lens, or, in other words, what is the nearest approach to parallel rays the eye is adapted for. The distance being known, we have only to apply such a concave lens before the eye as will give to parallel rays the same degree of divergency. Whatever the distance may be at which vision is distinct, but beyond which it ceases to be so, a lens of focal length equal to that distance, will change the parallelism of rays from distant objects into a corresponding degree of divergency before they enter the pupil, and thus the eye will become able to form proper retinal images of them as it did of the nearer objects without the lens.

Example:—A myopic person is found to see distinctly with each eye the smallest-sized type at 10″, but cannot see it properly with either beyond that distance. His myopia is said to be equal to $\frac{1}{10}$. If concave lenses of 10″ focus be now placed before his eye, he will be able to see distant objects. The parallel rays are made just as divergent by the −10″ lens, as they were from the type at a distance of 10″ without a lens.

A slight correction is necessary for the increased power of accommodation arising from the convergence of the optic axes when both eyes are employed in regarding the objects, and on this account the proper glasses for looking at distant objects will be found to be not quite so divergent as the number arrived at by the process just described. In the example given above, lenses of −12″ focus would probably be the exact glasses required.

The Range of Accommodation is not lessened in uncomplicated myopia. If the abnormal state of refraction of the eye be corrected by a suitable lens, the patient should be able to see from 3″ to 4″ distance up to ∞. If it be not so, the range of accommodation is lessened by some other cause, such as atony of the ciliary muscle, from overstraining by prolonged work at near objects, presbyopia, or other complications.

HYPERMETROPIA.

Definition.—Over-sight.—The converging power of the eye is less than normal, so that divergent, and even parallel, rays, are brought to a focus posterior to the retina. Only convergent rays are properly focused upon the retina.

Optical Causes.—In hypermetropia the refracting qualities of the transparent media are too low, or the antero-posterior diameter of the eye is disproportionably short, or both causes are combined.

Remote Causes.—Hypermetropia is sometimes due to Congenital Conformation, at other times it arises at the age of manhood, without any distinguishable cause. Occasionally it is induced by structural changes as age advances, beginning after the patient is 50 years old, and is then associated with *presbyopia.*

When slight in degree, it may not be noticeable at first, but is increased and rendered manifest by continued occupation at near objects, or in case of health becoming impaired.

Symptoms.—After looking intently for a short time at small objects, as in reading and writing, the letters become blurred and seem to run into each other. The vision of distant objects is also indistinct, and more limited in range than normal, though the patient himself often fancies he can see well at a distance. The hypermetropic eye cannot adjust itself for distant objects, as in trying to hit the bull's-eye at rifle practice. The patient often suffers from symptoms of *asthenopia* (see Asthenopia, p. 23). Hypermetropia is not unfrequently associated with a certain amount of convergent strabismus, and this circumstance arises in the following way. The hypermetropic eye being adjusted for convergent rays, and no such rays existing naturally, the accommodatory apparatus is subjected to a constant exertion, in order to give more convexity to the anterior surface of the lens, and thus to lessen the hypermetropic condition, and, with it, the indistinctness of the retinal images of external objects. This exertion is increased in proportion as the rays are rendered more divergent by objects being brought close, as occurs in reading. The patient unconsciously tries to relieve the excess of this strain on the ciliary muscle by contracting the internal recti muscles to avail himself of the increased accommodation for near objects associated with convergence of the optic axes. As, however, the point for which such a patient is able to accommodate his vision, is situated beyond the intersection point of the visual axes, the inconvenience of double vision would result from this, if both eyes were directed equally towards the object. One eye is, therefore, caused to converge more than the other, and in this way one of the images, falling upon a less sensitive part of the retina in one eye, is ignored mentally, or, in other words, ceases to exist so far as the sensorial part of the act of seeing is concerned. The repeated disproportionate action of the internal recti muscles for these purposes becomes habitual, and at last leads to acquired strabismus. It is for the purpose of neutralizing the ill effects of the strain upon the accommodatory apparatus, that, in the treatment of hypermetropia, convex glasses are recommended to be constantly worn. An hypermetropic condition of the eye may sometimes exist without attracting attention, when the compensatory power of the accommodatory apparatus is strong; but in such a case, if the patient becomes weakened in general health, the hypermetropia becomes obvious, because the ciliary muscle becomes weakened also, and loses some of the accommodatory power which previously was able to counteract the absence of sufficient converging quality in the transparent media.

Diagnosis is effected by the following modes of observation, namely, (1) by external signs, (2) by test-types, (3) by spectacles, and (4) by the ophthalmoscope.

1. *By External Signs.*—The eye is generally flatter and often smaller than normal, so that the space beneath and between the eyelids does not appear to be filled out. An abnormal hollow space exists between the eyeball and outer canthus.

2. *By Types.*—If the hypermetropia be severe, types cannot be read clearly at any distance without the aid of lenses; but if moderate, the larger and more distant type may be able to be read for a short time. The eye soon becomes fatigued and the letters indistinct. In trying to read, a tendency for the optic axes to converge will be noticed, and the patient will be observed to squeeze the eyelids together for the purpose of contracting the inter-palpebral fissure. The reason why the larger and more distant types are perceived with less difficulty than the smaller and nearer type, is that the accommodatory strain is increased in proportion to proximity of objects as the rays are proportionably more divergent.

When very small type is used, the hypermetropic person will be generally observed to carry the type near to his eye in trying to read it. He will be able to distinguish it better when close to his eye than at a distance of a foot or so away from it. The patient does so because, with the great convergence of the optic axes when the object is close, he is better able to apply his accommodatory power to counteracting the difficulties of reading, resulting from his hypermetropic condition of vision; and, in addition, because the retinal images of the letters are increased in size, and therefore more readily perceptible, while the circles of dispersion are not enlarged in anything like a corresponding proportion.

3. *By the Spectacles.*—When the convex 6″ spectacles are worn, the hypermetropic eye can neither see small type at 6″

distance from the eye, nor at any point short of that distance, because in the first case the rays falling upon the eye are parallel, and, in the second, are diverged. But at some point beyond the distance of 6″, so that the rays are made to converge to the pupil, the hypermetropia, if absolute, will be corrected and the patient see clearly. The test is only perfectly satisfactory when the power of accommodation has been previously taken away by paralyzing the ciliary muscle with atropine.

4. *By the Ophthalmoscope.* (See Part II., p. 53.)

To determine the Degree of Hypermetropia and its proper correcting Lens.—To effect these objects, the degree of convexity is sought for which will give rays which are nearly parallel the necessary convergence to enable them to be focused on the retina. If the hypermetropia be not severe, and the accommodatory power is fair, such convex lenses will serve to correct the defective vision for both distant and near objects. But if the affection be great, and the accommodatory power weakened from overstraining, a stronger pair of lenses will be required for close work, than is required for distant objects.

The ordinary method of determining the degree of hypermetropia is the following. The patient is desired to read one of the larger series of Snellen's types, (say that for 20 feet,) at the fixed distance, and he finds that he cannot. A weak, double convex lens is placed before his eye, (say one of 40″ focus,) and if this renders the type clear to sight, and neither a stronger nor weaker lens makes the type clearer, the degree of hypermetropia is described as $\frac{1}{40}$, and the proper correcting lens is of 40″ focus.

But from the habitual exercise of accommodatory power, the patient cannot observe the type, without putting it into action, so that unless steps have been taken to neutralize this, the full degree of hypermetropia has not been arrived at. It would be necessary therefore to use the strong solution of atropine,* and then examine vision again. Now, the patient not being able to exert accommodation, a stronger focal power than 40″ will be found necessary to render the type clear, and the focal distance of the lens that effects the object under the new circumstances decides the degree of hypermetropia.

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* Four grains to one ounce of water.

In severe cases of hypermetropia we proceed in the same way to ascertain the focal power of the lens which is required to correct the divergent rays from near objects, at 7″ or 8″ from the eye.

As, however, only the convex 6″ lenses are available in the regimental case for determining the degree of hypermetropia, it must be ascertained and expressed in the following way. Let D represent the distance at which an eye, after paralyzing the accommodatory power by atropine, can see a given type through convex 6″ lenses. Then H, or the degree of hypermetropia, $=\frac{1}{6}-\frac{1}{D}$.

Example:—Supposing the distance at which the type is seen under the circumstances described to be 7″, then $H=\frac{1}{6}-\frac{1}{7}=\frac{1}{42}$, the degree of hypermetropia, and +42″ is the power of the lens requisite for correcting it.

As the distance increases, the more convergent are the rays which pass into the eye, or, in other words, the higher the degree of hypermetropia, and the greater must be the degree of convexity of the correcting lens. Thus if D be equal to 8″, then $H=\frac{1}{6}-\frac{1}{8}=\frac{1}{24}$, and so on.

The Range of Accommodation in Hypermetropia can be readily ascertained when all effect of atropine has ceased, by using the correcting lenses, and proceeding as described under myopia. It may be defined according to the following formula. A being the range of accommodation, p′ the proximate and r′ the remote point of clear vision with the spectacles, $\frac{1}{p'}, -\frac{1}{r'}, =A$. Thus supposing accommodation to be strong, so that the near point with the spectacles is 3″, and the far point ∞, $\frac{1}{3}-\frac{1}{\infty}$, or $\frac{1}{3}$, will indicate the range of accommodation.

The two defective conditions of the refractive media just referred to may not only be simple, as supposed in the foregoing descriptions, but may be complicated with other causes of impaired vision not obvious to external observation, such as presbyopia, amblyopia, asthenopia, strabismal diplopia, and some other defective structural conditions which it is necessary to refer to separately.

Astigmatismus.

Definition.—A defective condition of vision depending upon unequal focusing power in the directions of the horizontal and vertical meridians of the globe of the eye.

In consequence of this defect when the images of objects are clearly formed on the retina in one of these directions, the images formed on the retina in the other direction across it are blurred and indistinct. It may depend upon corresponding differences in the amount of curvature of the horizonal and vertical meridians of the cornea, which has been shown to be its usual cause, [cylindrical eye,] or to an abnormal position or unequal curvature of the crystalline lens.

The difference in the distance at which objects arranged linearly can be distinctly seen in a vertical direction as compared with the distance required for distinct vision in a horizontal direction, indicates the degree of astigmatism.

Correction.—Astigmatism is corrected by lenses so formed as to act on one meridian of the eye only,—astigmatic lenses. They may either increase the refractive power in the direction of the one meridian, or lessen it in that of the other; by either means the focal power can be equalized in both directions. Such lenses must represent by their form portions of cylinders; the rays striking them in one direction will be then refracted as by an ordinary lens of corresponding curve, in the other direction they will pass through with no other refraction than that due to the medium through which they are transmitted.

Astigmatism having been found to be a much more common source of defective vision than has been hitherto supposed, attention should be directed to the question of this disability existing in cases when the diagnosis is not otherwise clear and satisfactory. The vertical and horizontal lines in Snellen's test-types offer a ready means of diagnosis for this defect. It can also be detected by placing between the eye and the sky or a brightened sheet of paper, a card with a small hole made by a pin in its centre. On slowly moving the card from the cylindrical eye, the hole will not appear to remain circular, but at a certain distance will change into a straight line, and at a still further distance this line will become changed in position, and assume a direction at right angles with its first direction.

Astigmatism may be complicated with a generally myopic or hypermetropic condition of the eye.

PRESBYOPIA.

Definition.—Vision of advanced age, characterised by being obscure for near objects. The "near point" is removed further than 8″ from the eye, while parallel rays are brought to a focus upon the retina.

Optical Causes.—There is no defect as to the refractive quality of the eye in simple presbyopia; it is neither myopic, nor hypermetropic, and neither concave nor convex lenses improve the sight for distant objects.

Remote Causes.—Natural changes from age. The near point recedes in all eyes in regular progression with increasing age; thus the change is a natural one, and advances with advancing years. The recession of the near point is said to commence as early as 10 years of age. At 40 years the near point is about 8″ from the eye, at 50 years from 10″ to 12″ from the eye, and so on. No inconvenience results until the near point recedes to about 9″ or 10″ The recession of the near point is not caused by any change in the refractive qualities of the several media, but is attributable to diminution in accommodatory power. As already explained, the employment of this faculty calls for exertion in proportion to proximity of objects, or divergence of rays. The gradual lessening of the range of accommodation is explained by the crystalline lens becoming more and more firm with increasing years, so that the ciliary muscle is incompetent to effect the same amount of alteration in its form. Observation has shown that the muscle itself is unaltered. It is doubtful whether the changes which occur in structure and curvature of the cornea may not also assist in causing the difficulty of adapting the eye for near vision. Diseased conditions, such as changes in the state of the lens capsule connected with posterior synechiæ after iritis, changes in the structure of the capsule or lens itself, weakness of the ciliary muscle, and the like, may induce the symptom of presbyopia at any age.

From the explanation just given of the nature and causes of presbyopia, it is evident that whether an eye be emmetropic, myopic, hypermetropic, or astigmatic, it will equally become subject to the complication of presbyopia with age.

Symptoms.—Presbyopia is not usually complained of till after 40 years of age, generally not till 45 years. The subject of it says that though he can see as well as formerly at a distance, he finds it troublesome to look at small objects near him. In reading he has to remove the print farther and farther from his eye. Then, on account of the distance he has to hold these small objects, he cannot see them accurately. To rectify this, he has to use magnifying glasses, and it is simply for the purpose of magnifying the small letters, and so enlarging the retinal images, not for correcting any abnormal weakness of refracting power in the eye that the convex lenses are used in simple presbyopia. The inability to effect the necessary changes in the lens for accommodation is compensated by giving to the objects larger visual angles.

Diagnosis.—The age of the patient, the usual evidences of the adjustment of the eye for parallel rays, as explained under emmetropia, with the distance of the near point, sufficiently distinguish presbyopia from any other affection. When either myopia or hypermetropia co-exist with presbyopia, there will be the evidences already described of these conditions in addition to those of presbyopia.

To determine the Degree of Presbyopia and its proper correcting Lens.—As presbyopia is held by most oculists to commence as soon as the near point has receded to 8″ from the eye, the degree of existing presbyopia is determined by finding the focal power of the convex lens which will bring back the near point to that distance. This is readily done in the following way. Ascertain the near point with the smallest type the patient can read, then deducting from this one-eighth of unity, the required focal power is indicated. For example, suppose the near point is found to be at 12″ distance from the eye, then $\frac{1}{12} - \frac{1}{8} = -\frac{1}{24}$. The degree of presbyopia is in this instance $-\frac{1}{24}$, and convex 24″ will be the proper correcting lens to bring back the near point to 8″.

The Range of Accommodation in Presbyopia is ascertained by the same formula as that described under hypermetropia, viz., $\frac{1}{p} - \frac{1}{r} = A$. In the instance above supposed of the near point being at 18″, while the eye is adjusted for infinite rays, $\frac{1}{12} - \infty = \frac{1}{12}$ indicates the range required.

WEAK VISION.

There are two descriptions of weak vision which it is necessary the observer should be able to distinguish in ocular examinations.

The first of these is termed amblyopia, derived from ἀμβλὺς, blunt, obtuse; the second is asthenopia, from ἀσθενὴς, wanting in force. The first refers to imperfection in the sensitive recipient elements; the second refers either to weakness in the internal structures which are engaged actively in adapting the dioptric apparatus to the varied requirements for clear vision, or to a deranged balance of power in the external muscular motors of the organ. It will be convenient to consider separately these conditions, which are very distinct in their nature.

I. Amblyopia.

Definition.—Feebleness of vision from diminished acuteness of retinal perception.

Impaired vision thus defined was formerly included with many other morbid conditions under the vague term of "amaurosis."*

Causes.—These may be either cerebral, or belonging to the optic nerve, or to its retinal expansion, and they vary greatly in their nature. Some of them are demonstrable by the ophthalmoscope, and will be described under their respective heads in the second part of this manual; others originating in the optic tract, or brain, are of course beyond its sphere of observation.

Just as retinal perceptive acuteness may be increased on a healthy subject by proper and constant practice at natural objects, so it may be lessened by want of employment, as generally happens with one eye in strabismus, whatever its kind. On the other hand, *amblyopia* may be induced by injudicious continued overstraining of the retina, under artificial conditions, as in prolonged work at minute objects, especially if the person be subjected to circumstances tending to impair general health, and the retina be over-stimulated, as by artificial light, or the bright glare of a tropical sun.

Although not a direct cause, absence of transparency in any of the refractive media may in time indirectly lead to *amblyopia*.

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* Amblyopia is sometimes used also to express the indistinctness of vision which is directly dependent upon obstructions or diminished transparency in the dioptric media. It is practically more useful to limit its signification, however, to the consequences of defective conditions of the optic nerve, and its retinal expansion.

When clearness of vision is lessened by corneal or lenticular opacity in one eye, while the other remains sound, the impaired and clouded eye will sometimes cease to act in concert with the normal eye, and strabismus result. There will not usually be *diplopia,* for the patient will be gradually led to use only the sound transparent eye for the act of vision. The inactivity of the retina in the other unemployed eye causes *amblyopia* to supervene.

Symptoms and Diagnosis.—In its mildest forms the patient simply cannot perceive minute objects. But it may vary in degree from inability to see the three or four of the smaller sizes of type up to inability to see more than the outlines of very large objects. Type of moderate size in reading is held closer to the eye than usual, in order to obtain larger images, and thus an inexperienced observer is liable to suppose the patient to be myopic. There is not usually the sense of effort or fatigue that accompanies asthenopia, nor the "blurred vision" or defective refractive power. When the amblyopia depends upon disease of a severe kind, it will be accompanied by characteristic symptoms. (See Retinitis, Atrophy of the Optic Nerve, &c.)

The following are also forms of amblyopia:—

(*a.*) **Hemeralopia,** or that condition of weak vision in which the patient states that he can see well in the daytime, but cannot distinguish objects after sunset. It is frequently found among soldiers who have passed from a northern latitude to a tropical station. In these instances it is evidently due to exhaustion of nervous power from over-stimulation by the bright light of the tropical day and the reflected glare from the water of the ocean, unrelieved by the variety of shade and colour which are met with on the land, and the consequent inability to perceive objects illuminated by the comparatively weak rays of moonlight. The amblyopia will be proportionably increased if circumstances have induced any scorbutic taint in the constitutions of the individuals affected. This description refers to simple hemeralopia; care must be taken not to mistake it for the diminished visual power which co-exists with atrophy and other changes of a grave nature to which the retina is liable.

(*b.*) **Nyctalopia,** which signifies the converse condition of hemeralopia, when the patient can see better after sunset than he can during the daytime. In this state the retina is weak, and unable to bear the stimulus of bright light, from hyperæsthesia, caused by inflammatory or other changes in the retinal structure. The intolerance to the bright light thrown on the retina by the ophthalmoscopic speculum is often an index to retinal changes in cases when there have been no previous symptoms indicative of inflammatory action. Such cases are not unfrequent among the soldiers who are invalided for impaired vision from India.

(*c.*) **Hemiopia,** and other conditions of depraved vision depending upon weakness or loss of retinal perception will be alluded to in Part II. When the fact of the existence of amblyopia is established, a true diagnosis of its cause can only be hoped to be arrived at by a careful study of the history of the case, and by ophthalmoscopic investigation.

II. ASTHENOPIA.

Definition.—Feebleness of vision from deficient or irregular muscular action; ("muscular amaurosis?")

Causes.—Over-fatigue, atony, or paralysis of the ciliary muscle. Weakness of the internal recti muscles, which are those chiefly employed in converging the eyes for near objects, as in reading. The symptoms which result from these sources are in many respects similar, but the origins being so different in nature, the principles on which treatment is conducted must be equally different. The two forms are, therefore, distinguished as (*a*) "accommodatory asthenopia" and (*b*) "motor asthenopia."

Symptoms.—The following are common to both forms of asthenopia. Reading and observation of near objects in general quickly induces fatigue. The effect of continued application of this kind causes a sense of fulness and tightness in the eyes, uneasiness about the brow, and perhaps headache. On trying to read, the letters at first appear clear and distinct, but afterwards become blurred, and, more or less, cross each other, (incomplete diplopia). Epiphora, and perhaps conjunctival vascular injection, follow, if the exertion be continued. The symptoms are relieved by rest, and generally, according to the length of interval of rest, so is the degree of relief.

Diagnosis, between Motor Asthenopia and Accommodatory Asthenopia.—The power of mobility of the eyes must be examined, more especially the power of convergence of the optic axes. In *accommodatory asthenopia* mobility is unimpaired, and the convergence of the optic axes perfect; in *motor asthenopia* the opposite condition exists. The following is the usual way of examining the amount of convergent power possessed by the asthenopic eyes. An object, such as a ruler, is held up before the face in a line midway between the eyes, about the distance of a foot off. This is slowly moved toward the face, and when only about half a foot off, attention is paid to ascertain if one of the eyes becomes unsteady and turns outwards. Should this happen after repeated observations, it shows that the internal rectus is too weak to keep the eye in an inward direction. Another plan is to shade one eye, and to direct the other at some object; if *motor asthenopia* be present, the covered eye will be moved by the stronger external rectus muscle, and turned more or less outwards. The relative strength of the converging and diverging muscles may be determined by testing their power of counteracting the deflection of rays from a given object by prismatic glasses of known varying degrees of strength.

(*a.*) *Motor Asthenopia* usually co-exists with *myopia.* If neglected, it will probably lead to permanent strabismus. The patient, in order to prevent the annoyance of the partial *diplopia* produced by continued exertion of both eyes together at near objects, will use one eye only; and the other then moves outwards, and, if habitually unemployed, not only squints, but is rendered amblyopic. It is by prolonged and graduated exercise of the internal rectus muscle, by use of suitable prisms, or by division of the external rectus muscle, that attempts are made to remedy this condition.

(*b.*) *Accommodatory Asthenopia.*—The cause of this form of *asthenopia,* namely, want of tone in the muscle of accommodation, at once shows that whatever condition of the eye induces an excessive strain on this muscle must aggravate, if it does not originate, the defect. Hence its constant coexistence with *hypermetropia,* and frequent occurrence with *presbyopia,* as well as the relief from the use of suitable lenses to correct these conditions.

But the loss of power in the ciliary muscle may be brought about by other circumstances. Paralysis from disease of the third nerve, or from its artificial production by the action of atropine, loss of elasticity from continued contraction by constant occupation at near objects, spasm, general debility, are quoted as other inducing causes of accommodatory asthenopia.

OTHER DEFECTIVE QUALITIES OF VISION.

It will only be necessary to allude briefly to the remaining defective conditions which influence quality of vision independent of defects resulting from obvious disease or injury. Some of them, if they exist to an extent to impair the power of sight required for the duties of a soldier, are at once seen in the ordinary examination of the recruit, while others are comparatively unimportant on account of their great rarity. The chief are (1.) *Strabismus,* and (2.) *Achromotopsia.*

I. STRABISMUS.

Definition.—Malposition of the two eyes relatively to each other, so that their visual axes have not corresponding directions when a given object is looked at.

Modern ophthalmologists for the most part adopt the views of Von Graefe, and recognize two forms of strabismus; one dependent directly upon muscular spasm or contraction, accompanying anomalous states of refraction or impaired vision of one or both eyes, under the name of "strabismus concomitans": the other indirectly produced by paralysis of one or more muscles of the eyeball, by traumatic injuries, or due to other causes situated within the orbit.

The strabismus is commonly convergent toward the median line; or divergent, being turned outwards. The deviation may, however, be upwards, downwards, or in respect to inclination. In convergent and divergent strabismus, the retinal images are separated laterally, but remain on the same plane; in the other forms of deviation they vary in altitude and inclination according as the superior and inferior recti or oblique muscles are involved. It may be single, or monocular, when there is malposition of one eye only; or double, that is binocular, when both eyes are affected.

The existence of *strabismus* necessarily causes the formation of double retinal images, but does not necessarily cause diplopia, or double vision.

Diplopia does not exist in a large majority of cases of strabismus, and this results from the fact that the patient acquires the habit of mentally avoiding the act of vision in one eye, and attending only to the images pictured on the other. When strabismal diplopia does exist, it may be the result of so slight an absence of concordance in the position of the images on the two retinæ that merely an appearance of haziness may be given to the object; or, in its full extent, the two images being placed in totally independent positions on the respective retina, there may be the complete appearance of two objects when only one exists. In convergent strabismus the two images are formed on the corresponding retinæ; that which appears on the right side belongs to the picture formed upon the right retina; that on the left side belongs to the left retina. In divergent strabismus the images are crossed and formed on the opposite retinæ: that which appears on the right side belongs to the left retina; that on the left side to the right retina. The relative positions of the images in some instances are almost the only means by which the surgeon is enabled to decide which particular muscles are disordered. Their respective situation will be rendered obvious to the patient at once if the two images are seen by him under different colours, so that he can distinguish them from each other. This object is effected by causing the patient to look with one eye through stained glass. As *diplopia* may result from the existence of certain lesions in a single eye, it is always necessary to ascertain whether the defect is due to strabismal malposition of the two eyes or to an abnormal condition of one eye only, as well as to determine in this latter case which eye is affected. These points are at once settled by closing each eye in succession. If the *diplopia* be strabismal, it will disappear as soon as either eye is closed; if the disturbance be confined to one eye, the alternate closure will show which is the eye disordered.

The existence of strabismus is, in most cases, conspicuous enough; but sometimes the natural balance of the associated or co-operative muscles is so slightly disturbed, or, in other words, the strabismus sometimes exists to so small an extent as to cause it to be by no means easy to decide at once whether there is or is not any want of harmony in the visual direction of the two eyeballs. But if any deviation be observed, however slight it may appear to be, it should attract the surgeon's notice and make him very carefully and thoroughly examine the visual power of each eye. If the strabismus has existed from childhood it will probably have resulted from some morbid condition of the parts in the fundus of one or both eyes; or, if it has originated in other causes, such as abnormal conditions of form or refraction, it will probably have induced retinal weakness or disease in them. If it has been of more recent origin it may serve to indicate some superficial defect of inflammatory origin, some defect of nervous influence, or even some cerebral disorder.*

II. Achromotopsia.

Definition.—Colour-blindness. A defective state of vision under which the subject though possessing distinct perceptions of form, light, and shadow, is unable properly to recognize diversity of colour, or even to perceive certain colours.

Red, and the tints approaching to this colour, are the colours which are most frequently inappreciable, or only very imperfectly recognized in *achromotopsia*. It is usually congenital, and is most probably due to some special structural condition of the retina, the nature of which is not at present understood.

This affection, which is still very obscure in its nature, though important as regards those who are guided partly by coloured signals, as railway officials and others, the physician in the diagnosis of diseases characterized by colour, as *scarlatina*, or even officers in command who are required to recognize clearly the colours of uniforms† is of scarcely appreciable importance in respect to soldiers in the ranks. Moreover the defect is comparatively so rare, that it may be excluded from consideration in the recruiting room. It may be of interest to remember in respect to soldiers already in the service that *achromotopsia* occasionally occurs as a temporary affection.

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* The most complete exposition in our own language, of the modern views respecting strabismus, and especially their bearing upon the question of surgical interference, will be found in Mr. Soelberg Wells's six lectures on Strabismus, lately published in the Medical Times and Gazette.

† I am aware of a musketry instructor who cannot distinguish the "danger flag" by its colour, but only by its larger relative size; of a general officer who is necessitated from the same defect to ask a member of his staff whether a soldier is dressed in red or blue; and I know a surgeon in civil practice who for some time was affected with achromotopsia, during which period he could not distinguish red colours. A patient affected with scarlatina appeared to him to be of a yellowish tinge, as if he were suffering from jaundice.

CHAPTER III.

Visual Examination of a Recruit.*—The Regimental Optical Case.—Mode of conducting the Examination.—Illumination of the Test Objects.—Pressure upon the Eye to be avoided.—Snellen's Types and corresponding Test-Dots.—Determination that Vision is Emmetropic.—Defective Vision.—Preliminary Examination of the Anterior Parts of the Eye.—Lateral Illumination.—Myopia.—Hypermetropia.—Presbyopia.—Amblyopia, how to distinguish from Myopia.—To distinguish Amblyopia accompanied by Myopia from simple Myopia.—Myopia simulated by Hypermetropia with great Accommodatory Power.—Detection of simulated impairment of Vision.

1. The determination of the *quality of vision* of a recruit, if it be not at once proved to be normal, will perhaps occupy 10 or 15 minutes. It is therefore best to make this examination after the rest of the inspection is completed, so as to allow the recruit to dress himself before it is commenced.

2. The regimental optical and ophthalmoscopic case is sufficient, in conjunction with the types and dots, for proving the quality of vision possessed by a soldier or recruit; it is not designed to show the exact degree of abnormality, supposing it to be proved to be defective. The degree of Myopia, or Presbyopia, may be expressed by signs as already explained, but to demonstrate their correction practically complete sets of lenses, both convex and concave, are necessary. Sets of lenses have the advantage of offering additional facilities for detecting attempts at imposition, and solving complicated and doubtful cases, and are therefore especially useful in general hospitals.

3. All rooms in which the examination of recruits is conducted should be well lighted. This is especially important in testing vision. The light falling on the test-objects to be looked at should as nearly resemble the degree of external daylight as possible. It is a matter of convenience in saving time to have some lines, showing distances in feet, permanently marked upon the floor,

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* Although the remarks in this chapter are more particularly applied to examining the visual power of men *seeking* enlistment, they are equally applicable to solving cases of doubt, and determining the kind of defective vision, if it be proved to exist, of soldiers already serving in the ranks of the army.

especially if Dr. Snellen's types or the miniature bull's eyes are used.

In conducting the examination the recruit is placed with his back towards the light, so that the fullest illumination is upon the types or dots by which his sight is tested. When Dr. Snellen's types are used, one of the smallest kind of type is selected, placed at the distance in feet indicated by the figure above it, and the recruit is then asked to read it, both eyes being open. If read with facility there is no probability of anything abnormal existing. But it is always necessary to test each eye separately.

4. Musketry instructors naturally direct attention principally to the right eye, because it is with this eye that the recruit is taught to aim at objects; but the existence of defect or disease in either eye is a sufficient cause of medical rejection of a recruit. Though the right eye may be sound, if the vision of the left eye be defective in any marked degree, especially if the defect be the result of diseased action, not simply of conformation, we must remember that it is not improbable the vision of the right eye will eventually become defective also. Moreover, as regards recruits, the chances of the normal eye becoming affected by disease originating in the exposure and causes incidental to military service, have their influence in determining the rule that not only the right eye, but the left also, of the recruit should be ascertained to be normal before his being passed fit for a soldier.

5. In examining the eyes separately, it is best for an assistant to close the eye not occupied in regarding the object, and not the recruit himself. If the recruit be allowed to close it, he will probably, from carelessness or nervousness, exert undue pressure on the globe, and so disturb its condition for vision, and cause delay until this disturbance is recovered from. The assistant who closes the eye should be taught that if pressure be made it should be limited to the margin of the orbit. The object is simply to exclude light by closing the lids and shading with the hand; the eye should not be pressed upon. If undue pressure has been made, it will be necessary to wait a minute or two until all mistiness of vision has disappeared before applying the test for visual power.

6. If Dr. Snellen's types are used, and the recruit can read with each eye successively the small types at the given distances, the sight is emmetropic and of normal power. If any doubt has

been raised, this can be readily further tested by trying the recruit with any of the other sets of types: as the sizes and distances are in regular proportion, they should all be seen with the same facility.

7. The types, and all similar objects, should be held upright and on a level with the eyes of the person under examination.

8. If the recruit is unable to read, the sight may be tested in the same way by Snellen's figures, or dots of corresponding sizes.

9. By a recent circular * it has been ordered that no men shall be received into the service who are unable to see distinctly a black centre, or circle, three feet in diameter, on a white ground up to 600 yards at least. It will, of course, be rare that an actual range of this distance can be obtained for the examination, and even if one can be got, and targets with centres of the size named are placed in position, it will be found practically difficult to settle whether they are seen, or not, excepting on the bare assertion of the person under observation. Black centres, or test-dots, have therefore been devised of a proportionate size for a distance of ten feet. A group of these centres at certain distances apart from each other is shown to the man who is trying to pass as a recruit, and, if his power of sight is as strong as is required by the circular, he will be able to describe their number and relative position.† These miniature centres will only answer the purpose explained; they will not assist in determining whether a man who states that he cannot see them is telling the truth.

To avoid the inconvenience of having a series of eight or ten cards with distinct groups of dots, the dots have now been printed in a large group together, so arranged that, when an examination is being made, a certain proportion of them are covered by a separate piece of card, held in the hand of the examiner, and the recruit is required to name the number and relative position of the dots which are left uncovered. In this way the examiner can vary the number of dots remaining visible according to discretion.

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* Circular, $\frac{21410}{8\,\text{E}}$; $\frac{\text{Medical,}}{\frac{2}{63}}$ 3rd December 1863.

† These test-dots have been published in a compact form, accompanied by brief instructions on the manner of using them, and have been issued to army surgeons from the War Office at the recommendation of the Director General of the Army Medical Department.

When fixed numbers of dots in a series of groups have been used, it has been found that recruits have been made aware of the numbers on the cards, and deception thus practised.

10. It is necessary next to describe the course of proceeding in case a recruit appears unable to read type or dots at the normal distances, and the existence and nature of his disability have to be determined. The disability must arise from one of the conditions described in the preceding chapter.

Immediately that it is perceived vision is defective, closer attention should be paid to the examination of the superficial structures of the affected eye. The cornea, anterior chamber, iris, and crystalline lens should be subjected to minute observation. Defects may exist in these structures sufficient to obscure vision without their having been perceived in the observation of the organ made at the general inspection of the recruit. This preliminary inspection is important, and should invariably be made. Considerable time is often lost when it is neglected.

11. The superficial examination is very rapidly made by *lateral illumination,* and indeed can only be thoroughly accomplished by its means. Lateral illumination implies alighting up of the parts required to be observed by concentrating upon them a pencil of rays cast in an oblique direction. The recruit is brought near the window of the room, one of the large biconvex lenses in the optical case is placed vertically near the outer angle of the eye in such a way that the light passing through it is made to converge upon the cornea, and its condition then examined by the spectator standing in front. This lateral illumination is of course more brilliantly seen in the ophthalmoscopic room, but is sufficiently marked by solar light on any ordinarily clear day. By these means the slightest roughness of the surface of the cornea, interstitial haziness, minute ulcers or the remains of them, fine exudations at the margin of the pupil, posterior synechiæ, commencing cataract, are made most obvious to sight, while the pencil of rays is made to play upon each structure at pleasure. Nothing can be more beautiful than the perfect precision with which opacities of the cornea and lens, adhesions of lymph to the capsule, and other morbid changes, scarcely perceptible by ordinary observation, are defined by light

thrown laterally upon them in the manner just described. If minuter observation be required, the objects while thus illuminated may be magnified by an ordinary magnifying glass held in front of the eye, without impairing their brilliancy or distinctness of outline.

This preliminary examination of the eye having been made, and nothing abnormal detected, the examiner proceeds to notice the character of the defective vision under which the recruit labours.

12. *Simple Myopia.*—The recruit, not being able to read types or count dots at the normal distance, is found to be able to read or count them at some distance short of it. The external signs described in the general remarks on *myopia* will probably at once indicate to the surgeon that no simulation is being practised, and show the nature of the affection. The shortest way is at once to use the convex spectacles, and establish the diagnosis as explained in the last chapter.

13. *Simple Hypermetropia.*—The difficulty which the hypermetropic recruit exhibits in seeing the types and dots at any distance, and the form of the eye, will probably show the affection under which he is labouring. The diagnosis may be established as explained under *hypermetropia* in the preceding chapter, by the convex spectacles.

14. *Simple Presbyopia.*—Here the age of the man will probably be a guide to the affection. The diagnosis of this condition is also explained in the preceding chapter.

15. *To distinguish Amblyopia from Myopia.*—If it is found that the smallest sized types and dots cannot be distinctly seen at any distance, and that larger sized type is held nearer than normal to the eye, the recruit is probably labouring under *amblyopia;* he cannot be affected with simple *myopia.* To ascertain if this is the defect he is troubled with, weak concave lenses, if these are at hand, are placed before his eyes. If he now sees distant objects of apparent small size worse than before, his defect is probably amblyopia; for the concave glasses which would improve vision if he were myopic, renders vision worse in *amblyopia* by diminishing the retinal images. Again, when the convex 6″ spectacles are placed before his eyes, if the defect be only *amblyopia,* he will be able to see type of moderate size at a distance of 6″ from the lenses.

16. But *amblyopia* may be complicated with myopia, and it is important to distinguish simple short-sightedness from such a complication. Now, in this case, when the convex spectacles are worn, the subject will see types up to some distance within six inches, say, for example, four inches. The patient's true far point is then found thus:—$\frac{1}{4}-\frac{1}{6}=\frac{1}{12}$, and if the *myopia* be uncomplicated with *amblyopia*, he will be able to read the smallest type at that distance, 12 inches, without the aid of lenses. If it be complicated with *amblyopia* he will only be able to read some of the larger types at that distance. Again, we know that *myopia* alone, being an anomaly of form or refractive power of the eye, is completely corrected by suitable lenses, and thus a ready mode of establishing an exact diagnosis between simple *myopia*, and *myopia* with *amblyopia*, is also afforded by the following proceeding. Having proved the existence of *myopia* according to the methods already explained, the degree of *myopia* is next determined. The proper concave lenses to correct this *myopia* are then applied, and with them the simply myopic person will be able to see plainly the smallest sized types and dots at their proper distances; but if he be also amblyopic, he will only be able to see clearly types and dots of larger sizes according to the degree of *amblyopia*. By referring to the description of the causes of *amblyopia* it will at once be seen that the concurrence of *amblyopia*, if at all extensive, with *myopia* is a grave complication: it indicates the existence of disease, and not merely peculiar conformation. The nature of this disease must be solved by ophthalmoscopic examination.

17. A difficulty which occasionally presents itself is the following:—A soldier may be unable to see the bull's eye at far ranges, but may be able to distinguish some objects nearer than the normal distances. This condition will probably at first be attributed to the existence of *myopia*, but, on applying concave glasses, all objects will be rendered more indistinct. If we now apply convex glasses, distant objects will be rendered clearer. Here the evidence shows that the soldier is labouring under *hypermetropia*, but that by exercise he has gained great power of accommodation for near objects. If the convex 6″ spectacles are placed before his eyes, his most easy distance for distinguishing the types or dots will generally be at some point beyond six inches under any circum-

stances, but especially so if the accommodatory apparatus has been paralyzed by atropine.

18. One eye may be *myopic*, the other not so, but *presbyopic.* This condition will be indicated by the lens which corrects the defective vision of one eye failing to do so in the other, followed by the usual diagnostic tests. The presbyopic condition of the one eye in such a case may be induced by changes consequent on inflammatory action, posterior synechiæ, for example, and not by age.

19. It will not often be found even in normal eyes that the absolute focal lengths of the two eyes, independent of accommodatory exertion, are precisely alike : but in defective conditions of vision the difference between them is usually more marked. To correct the defective sight in such cases, lenses of different focal powers are of course necessary.

20. The question has been asked whether, supposing a soldier maintains that he cannot see clearly the bull's-eye at any range, that no description of lens improves his vision, and that no cause of disability is apparent, it can be proved that he really does see clearly enough for duty? To a certain extent the surgeon must be guided in such a case by circumstantial evidence and observation. A cross-examination, instituted with ordinary judgment, will usually expose the attempt at fraud. But in such cases the lenses become very useful : with the convex spectacles before his eyes, a trickster will almost certainly become confused, and will either see types or dots at distances which show that his vision is normal for distant objects, or he will overstate his case by saying he cannot see at all at any distance. If he says that he sees at any particular distance, the surgeon can notice whether, after varied changes, he always returns to the same distance as affording clear vision. Should he be sharp enough to do so, the surgeon notes the distance at which the objects are seen with the spectacles, and ascertains whether this proportionate distance is preserved under all stages of the examination.

If the man is able to read, the distance at which a given type is read may be noted, and observation made whether he reads the larger types at proportionate distances. If he should state he is not able to do so, and he still maintains that neither concave nor convex glasses make distant objects clearer, he must be trying to deceive. Where there is a command of lenses of many varieties of focal range, the demonstration is more easy.

I would not, however, wish it to be inferred from the above remarks, that I believe attempts at fraud, in respect to defective vision, are frequent among soldiers in the ranks. On the contrary, my experience leads me to believe that in the greater number of instances which have been suspected to be instances of deception, real disabilities have existed, though their true natures have not been ascertained. Suspicion has been excited in these cases, because the determination of the existence of the particular defective conditions of sight, under which the soldiers were labouring, was not included in the surgeon's range of diagnosis.

SECOND PART.

Ophthalmoscopic Examination of the Eye.

Chapter I.

Description of the Ophthalmoscope in the Regimental Case.—Care required for keeping it in serviceable Order.—Objects effected by the Ophthalmoscope.—Why Points in the Fundus of the Eye cannot be seen without its Aid.—Arrangements of the Ophthalmoscopic Room.—Exclusion of sunlight.—Artificial light.—Position of the Patient.—Position of the Surgeon.—Mode of acquiring the use of the Instrument.—Examination by the Direct Method.—Examination by the Indirect Method.—Appreciation of these Methods.—Mode of bringing the several Objects of the Fundus into View.—Obstructions from Spectra in the Object Lens or Cornea.—Artificial Mydriasis.—Different effects of Atropine according to Strength.—The Calabar Bean.—The System to be pursued in Ophthalmoscopic Examinations.

In the first chapter of the first part I gave a brief description of the lenses supplied for the *optical* examination of the eye, in the combined optical and *ophthalmoscopic* case supplied to Army Medical Officers. I have now to describe the instruments contained in this case for the *ophthalmoscopic* examination of the eye.* I do not propose to refer to the numerous varieties of ophthalmoscopes which have been devised since the discovery of Helmholtz first made it possible to bring into view the several structures of which the fundus of the eye is composed, but simply to point out the objects of the several parts of the instrument in the military case, and the manner of using them.

This instrument is known as Liebreich's ophthalmoscope from the name of its designer, and consists of the following parts:—a speculum, fitted with a moveable clip for holding ocular lenses; 5 ocular lenses; and 2 object lenses.

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* This case complete, containing both the optical and ophthalmoscopic instruments described in this manual, can be obtained from Mr. Pillischer, the optician in New Bond Street, for 25*s*.

The speculum is a concave mirror of four inches' focal distance. It is made of bronze metal, the surface of the mirror being coated with polished silver. In the centre of the mirror is a small opening about $\frac{1}{10}''$ in diameter, which expands into a funnel-shaped depression at the back of the speculum. By this means the margin of the opening is reduced to the narrowest dimension. This opening is the sight-hole. Attached to one side of the speculum by a double hinge is the ocular clip, so arranged that when one of the ocular lenses is placed in it, the lens can be laid directly upon the back of the sight-hole, their centres being in concert, or it can be removed on one side out of the line of vision at will. The whole is supported on a handle three inches in length.

The lightness and handiness of this form of speculum makes it very convenient for the operator's use. Some mirrors are made of silvered glass, but they are too fragile for military service, and if pierced by a central opening, the opening is usually left too large, and the thickness requisite to give the glass strength necessitates it being so deep that the examiner's view is disturbed by the light reflected from its sides. If there be no opening, but merely a circular space left unsilvered, then the clearness of the view is lessened by looking through the glass medium. It is very important that the sight-hole should be thin at its margin, and as small as is consistent with vision through it; for the thinner the edge the less interference there will be with the rays coming from the object under observation, and the smaller the diameter, the less break there will be in the central illumination thrown upon the object. The only precaution to be taken with the speculum is, not to polish it with materials calculated to scratch its silvered surface, and to take care, after using it, to replace it in its case, so that it may be kept dry and oxidization be prevented. Only ordinary care is necessary for keeping it always in a serviceable state.

There are four concave and one convex ocular lenses in the case; their focal distances are marked upon them. They can each readily be fixed in the clip, and are chiefly intended to correct defects in the visual power of the observer. The two object lenses are double-convex lenses of $1\frac{3}{4}''$ and $2''$ focal distance; they are employed to modify the direction of the rays coming from the objects under examination in the observed eye.

The following five objects are effected by the use of the ophthalmoscope :

1. A large amount of light is concentrated upon the fundus of the observed eye.

2. The observer's eye is shaded from the direct light of the flame or source of illumination.

3. The observer's head is so placed as not to intercept the light in its passage to the eye under examination.

4. The observer's eye is in the line of reflected light emerging from the eye under examination.

5. The rays which emerge from the observed eye are modified in their direction, so as to be brought to a focus upon the observer's retina, by suitable lenses.

It is because these several objects cannot be attained without the aid of such an instrument, that the back part of a healthy eye is always in shade, and the pupil always appears black to an ordinary observer : just as the entrance to a cave, which may be light enough to those inside, appears black to one looking at it from a distance standing n the broad glare of sunlight. To understand this, one has only to consider the smallness of the pupil compared with the size of the inner chamber of the eye and the moderate amount of light which can, therefore, pass into it naturally, together with the provision made against reflection of this light by the darkened choroid ; secondly, the impossibility of looking into a person's eye closely without the head of the observer shutting off the greater part of even the amount of light just referred to ; and thirdly, the difficulty which arises from the refracting properties of the eye and the consequent extreme nicety of focal adjustment which would be necessary for one eye to adjust upon its retina rays passing from the retina of another eye without artificial aid. From all these reasons, although a general luminous appearance under certain circumstances of the fundus of the eye had been previously noticed, no one had been able to see particular objects behind the pupil until the invention of the ophthalmoscope.

In commencing the use of the ophthalmoscope the surgeon must direct his attention to the room where it is to be employed, the source of illumination, and the mode of manipulating with the instrument; as well as to numerous other details to be noticed subsequently.

(1.) *The Room.*—Any ordinary room from which daylight can be excluded by shutters or thick curtains serves for ophthalmoscopic observation. The room should be darkened as completely as possible. It should not contain any bright reflecting objects. There should be only one flame or source of light. The purpose is that all reflected light may be prevented excepting that which is intentionally thrown into the fundus of the eye by means of the mirror. The room used at the Army Medical School has its ceiling and walls of a dull deep-black colour, all daylight is excluded, and hence, when the patient sits with his back to the flame, there are no reflected rays to fall upon him, the contrast between the darkened face and illuminated fundus is greater, and a less amount of illumination serves to bring distinctly into view the objects to which the observer is directing his attention.

A room so darkened, however, is not absolutely necessary. The fundus can be lit up in ordinary daylight by concentrating the light of a lamp upon it, but the objects in it will be less clearly seen. They will make fainter images upon the retina of the observer in proportion as the daylight is brighter, on the same principle that, although the stars transmit the same amount of light to the eye by day as by night, they will not be visible at the former time through the greater brightness of the diffused sunlight.

The only necessary furniture of the room is a small table on which the light is placed, with seats for the patient and surgeon.

(2.) *The Flame.*—Any moderately bright light that is not flickering will answer the purpose. The more colourless the flame the better. If a gas burner be not available an ordinary argand lamp will well supply its place. If a lamp be not at hand a wax candle will serve the purpose for one who is used to the ophthalmoscope, especially if the room be well darkened. When gas, or an oil lamp, is used, a glass chimney of a blue tint causes the light to be more neutral in colour. The light should have such a support as to place it nearly on the same plane as the patient's eye.

(3.) *Mode of using the Ophthalmoscope.*—In describing the manner of manipulating with the instrument it is requisite to note the position of the patient relatively to the ophthalmoscopist, and to explain several modes of examination to which the instrument may be applied. In the following remarks it is presumed that the examiner uses his right eye for observation of the examined eye.

(4.) *Position of the Patient.*—The patient should be in a sitting position, the light being behind his chair. His head should be erect, and, if possible, supported at its back to obviate fatigue, and secure steadiness when under observation. The chair should be so placed relatively to the light, that the latter is on a level with the patient's eye, and a little to the left of him, in a line with the edge of his left shoulder.

(5.) *Position of the Surgeon.*—He should sit on a stool opposite to the patient, his eye being on the same plane with the eye to be observed. The surgeon, while sitting, will be able to make longer and closer examination unfatigued than if he were standing. He will rise naturally and assume other positions in case he finds a difficulty in getting the patient to bring the different parts of the fundus into view according to oral directions.

(6.) *Illumination of each Eye.*—By the relative positions just named of the flame, the patient, and the surgeon, when the patient's left eye is examined, the surgeon can look through the sight hole without any slanting of the speculum, or other inconvenience, at the same time that he reflects the light fully upon the fundus of the eye before him. When the right eye is to be examined, all the change that is necessary is to cause the patient to incline his face slightly toward the surgeon's right, so as to gain the necessary angle of reflection for lighting up the fundus.

In commencing the use of the instrument, the best way is to practise at first with the speculum alone, until the power of concentrating luminous rays on any particular spot is acquired, and the eye is able at the same time to observe the illuminated spot through the sight hole with perfect ease. This can be acquired by employing any ordinary object for the practice. It is necessary next to exercise oneself in working the speculum and object lens together, the observer's head being moved with the speculum backwards and forwards in the line of the optic axis until a clear image is obtained. In applying the object lens before the observed eye, the tip of the middle finger may rest lightly on the patient's brow: this *point d'appui* enables the requisite but limited movements for the adjustment of the object lens to be made with more freedom and precision.

Some ophthalmoscopes are arranged to be fixed to the side of the table, with the object lens and speculum connected in such a way that the distance between them can be varied according to circumstances, at the same time that the necessary relations in respect to direction are mutually preserved. Although, however, there is at first a certain amount of difficulty in manipulating with the speculum and object lens detached from each other, necessitating as it does separate but concerted adjustment, yet when the difficulty is overcome, the advantages of the freedom of operating, and the complete power of controlling the movements of the instrument afforded by this method, more than compensate for the labour expended in its acquisition.

There are two modes of examining the eye by the ophthalmoscope. They are named the *direct* method, and the *indirect*.

The Direct Method, or mode for observing the erect image. In this method the speculum is used alone, and an illuminated object in the fundus of the observed eye is imaged directly upon the retina of the observer. The accommodatory power of the patient's eye must be paralyzed by atropine, and the surgeon's eye brought very close, from one to two inches, to the patient's eye, so that it may receive the rays as they emerge nearly parallel from the illuminated fundus. If the eye under observation be myopic, the reflected rays will emerge convergently, and will have to be made divergent or parallel by means of one of the concave ocular lenses fixed in the clip. The same rule applies if the examiner be himself myopic. By this direct method the image is inverted on the retina of the examiner, but is seen as an enlarged image of the object in its erect and real direction, projected apparently beyond the patient's eye. This method is ordinarily applied to the examination of particular points in the fundus of the eye, only a small portion of which can be seen at one and the same time.

There is another direct method of examination, but rarely had recourse to, in which, if the eye be emmetropic, an inverted image of the object is obtained. Here the speculum and eye of the observer are placed at a considerable distance from the observed eye. From the refracting quality of the eye, regarded as an optical instrument, the rays proceeding from any object in its fundus will be brought to a focus in front at a distance equal to its anterior focal length, or in other words, the distance of distinct vision. This aerial image will be considerably enlarged and reversed. To detect it the surgeon must place himself at a distance from it, about 8″ or 10″, according to his length of distinct vision; but, in consequence of the comparatively few luminous rays entering into its composition, the image is so exceedingly indistinct, as to be hardly discernible under ordinary circumstances. In certain abnormal conditions of the refracting quality of the eye, this mode of examination, as will be noticed hereafter, can be turned to useful account. It is also useful in examining the condition of the transparent media of the eye.

Indirect Method.—Here the illuminated eye is looked at with one of the biconvex lenses interposed between it and the speculum. The effect is to increase the convergence of the rays going to illuminate the fundus of the eye, and also to cause the reflected rays returning from the fundus to converge to a focus between the lens and the mirror, and there to form an image which is seen by the examiner looking through the sight-hole. By this indirect method the image depicted on the observer's retina is in its real direction, but is mentally seen as an inverted image before the eye. It appears also enlarged, but not so much so as in the direct method, so that the whole of the fundus of the eye can be very distinctly observed. The image is strongly illuminated in consequence of all the luminous rays reflected from the fundus of the eye being concentrated upon it by the action of the convergent lens.*

Of these several modes, the indirect method of examination with the biconvex lens is that which is ordinarily employed. The view which is gained at one and the same time of a large part of the fundus, so that the parts can be studied in their several relations to each other, and the rapidity with which observations can be made, owing to the clearness and brightness of the images formed by its means, are exceedingly useful in practice. Occasionally it is necessary to examine some point more closely, and then the direct method for obtaining the erect image is resorted to with advantage.

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* *Concave Object Lens.*—A concave object lens might be substituted for the biconvex object lens. By this means a considerably enlarged image would be projected apparently behind the eye, having the same direction as the real object, but an image so produced is very indistinct, and the effort to observe it so strains the accommodation of the observer as to prove quickly fatiguing and painful. This method is scarcely ever employed, and on this account the case supplied to regiments does not contain a concave object lens.

In employing the indirect method, the observer holds the speculum in his right hand, close to his own eye, and the biconvex lens between the thumb and forefinger of his left hand, from half an inch to an inch and a half from the patient's eye. The speculum is held so as to receive the luminous rays, and to reflect them upon the eye under observation, at the same time that the observer's eye receives the returned rays from the illuminated fundus transmitted through the object lens and sight hole. Some little dexterity is required for this manipulation.

When a clear view of the *optic entrance*, and vessels of the fundus (not merely of the generally illumined fundus), has once been attained, it will be necessary to acquire the faculty of bringing each particular object of the fundus under observation at will. The optic nerve enters the eye through the schlerotic and choroid about $\frac{1}{10}$th of an inch to the inner side of the axis of the eye. A ready means of bringing the *optic entrance* into view, if it be that in the right eye, is to desire the patient to fix his sight upon the top of the observer's right ear: if it be that in the left eye, to look at the same part of the left ear. If the patient carries out this direction, the optic papilla will be brought opposite to the observer's eye. But, from various causes, patients not unfrequently cannot obey these directions, and the optic nerve can then frequently be arrived at by tracing up the retinal vessels to their origin, and by directing the patient as to the way he is to move his eye in order to assist the observer in attaining his object. To bring the *macula lutea* into view, the patient is desired to look straight at the sight hole; or, if the patient has not the required power of sight, its situation can be found by the peculiar arching of the retinal vessels above and below it. It must not be forgotten, when seeking to bring into view any particular portion of the periphery of the fundus, that all the parts of the fundus are reversed by this method of examination, and the movements of the eye must be directed accordingly.

In practising with the ophthalmoscope, the positions described should be constantly preserved, and the operator should accustom himself to using the same glasses. By these means differences in size and in the shading of objects will be better appreciated.

Small images of the speculum are in certain relative positions formed upon the object lens, and frequently give rise to annoyance when they appear near the axis of vision. In like manner the cornea sometimes becomes the seat of images produced from pencils of luminous rays proceeding from the surface of the object lens. The nature of these spectra is readily perceived, and the interruption they cause can be got rid of by a little adroit inclination of the object lens to the right or left, or turning it on its horizontal axis, without disturbing the picture of the fundus.

Artificial Mydriasis, or Dilatation of the Pupil.—If the iris is not paralyzed by disease, it is necessary to dilate it artificially before making an ophthalmoscopic examination of the eye. The pupil will otherwise contract to its utmost under the stimulus of the concentrated light, and a small pupil interferes with observation in two ways; 1st, by limiting the amount of light that can enter the eye; and 2nd, by limiting the field of view of the observer. Mydriasis is effected readily and speedily by a solution of atropine.

Atropine is employed with two objects in view in examinations of the eye. One is simply to dilate the pupil, for the reasons explained above: the other is to paralyze completely all accommodatory power, as when it is intended to ascertain the exact refractive power of the eye, independent of the variable adjusting qualities from muscular exertion. For the first purpose two or three drops of a very weak solution of atropine are sufficient (one or two grains to the ounce of distilled water); but, for the second purpose, at least four grains to the ounce are necessary, and then its action must be excited for some time before the paralysis is complete.

For ordinary ophthalmoscopic examination, especially when the instrument has to be carried to the patient's dwelling, the most convenient way of applying the atropine is, perhaps, by means of paper which has been saturated with the solution and dried. A small portion of this paper inserted under the eyelid will soon produce the required mydriasis. But for precise optical examination it is necessary to have at hand a drop-bottle of the four-grain solution.

An objection existed to the use of atropine until lately. This was the confusion of vision, especially for near objects, which was caused by the paralysis of the iris and disturbance of accommodatory control, together with the length of time, five or six days probably, to which the patient was subjected to these inconveniences. This objection has been removed since the discovery of the antagonistic properties of the Calabar bean. The dilatation so readily effected by the atropine can now as readily be removed by the use of a few drops of the Calabar bean solution, or by inserting some paper prepared in the same way as the atropine paper. In practice, the strength of the Calabar bean paper must of course be proportioned to that of the atropine paper.

A small supply of each paper can be very easily kept for use in the ophthalmoscopic case, when it is not convenient to employ the drugs in the form of solution.

Systematic Examination of the Eye in all Cases.—Much loss of time may be avoided, and a more satisfactory result arrived at, by adopting a regular system, in ocular examinations. Supposing a case of disordered vision, presumed to be connected with deep-seated disease, to be brought for investigation, the following should be the successive steps taken for its elucidation :—

1st. As clear and connected a history of the defect or disease should be obtained as possible.

2nd. The optical examination should be made to ascertain the quality and power of vision.

3rd. The field of vision should be observed and determined.

4th. The ophthalmoscopic examination should be made step by step; and for that purpose, the state of the cornea, pupil, and lens should be first examined by lateral illumination.

5th. The same structures, together with the vitreous humour, should next be examined by the direct method.

6th. Lastly, the fundus should be examined by the indirect method. In examining the fundus, the optic entrance should always be first sought for; and, starting from it, the *macula lutea* and all other parts of the fundus should be successively explored. If both eyes have been prepared for examination, it saves time to make the examination by lateral illumination, and by the direct method, of each eye successively, before proceeding to examine and compare the background.

Mode of examining and determining the Field of Vision.—This is frequently of great assistance in arriving at a correct diagnosis of the extent of visual derangement, and also in marking the progress which the diseased action may make. The shape of the field of vision is obtained by causing the patient to look at a given point, and, while the eye is thus fixed, by drawing an outline of the boundary of distinct vision in all directions around it. The most convenient plan is to place the patient at a distance of about a foot in front of a black board, on which, at a level with the eye under examination, a small cross in white chalk has been drawn. The patient is desired to fix his eye on this cross. At the same time the surgeon, who must watch that the patient does not take his eye off the cross, holds the piece of chalk between the fingers of his right hand, and carries it from point to point over the board by slight quick movements of the hand, jotting down the points in various directions when it ceases to be seen. These points are now joined together by lines, and thus an outline of the shape of the field of vision is formed. If the map thus made be copied on paper, it can be retained for comparison with other diagrams to be made in a similar way on future occasions.

If it be important to ascertain the field of vision with great precision, separate outlines can be obtained by a similar plan showing where distinct vision ceases, and more externally where imperfect vision ceases and complete absence of sight begins. Remarkable irregularities of form, and limitations in extent, of the field of vision will occasionally be made manifest by this mode of examination in cases of *amblyopia* depending on certain diseases of the optic nerve and retina.

When it is not required to make a picture of the field of vision, but only to ascertain quickly the extent of the field, or whether there is any break in it in any given direction, the following method will answer the purpose readily and quickly. The surgeon, standing face to face with the patient, desires him to close one eye, the right, for example, and at the same time closes his own left eye. He now desires the patient to look steadily into his right eye, and while the two eyes, the one of the surgeon and the other of the patient, are thus directed to each other, the surgeon moves his forefinger around the field of vision. He is thus able to note the extent of the patient's range of vision, by comparing it with his own range. This ready method has the advantage of being capable of being put into execution anywhere without need of any appliances or previous preparation.

Records in the Ophthalmoscopic Room.—A slate for the purpose of pencilling down sketches, and noting brief memoranda of the observations made while using the ophthalmoscope (which should always be recorded at the time of examination), is an useful appendage to every ophthalmoscopic room.

CHAPTER II.

Ophthalmoscopic Appearances of the Eye in its Normal State.—General Effect of illumining the Retinal Interior of the Eye.—The colour of the Fundus. —Various Appearances of the Optic Disc.—The Colliculus.—The Retinal Vessels.—Lamina Cribrosa.—The Retina.—Position and Appearance of the Macula Lutea.—Various Conditions of the Choroid Tunic, and their Effects upon the Appearances presented by the Fundus.—The Refractive Media.

The following are the appearances presented by the interior of the globe of the eye in its normal state when examined by the ophthalmoscope.

The view which is first obtained when the interior of the globe of the eye is illuminated by the speculum is simply the appearance of a bright pink light through the pupil instead of the usual black colour. On looking attentively, the examiner sees that he is looking into a cavity, but nothing more than this coloured brightness is observable. The only reason why no distinct objects are seen, is that none of them have yet been brought to the proper focus so as to form images on the retina of the observer.

But when the proper focus has been found, by the means described in the previous chapter, the pink haze resolves itself into a definite back ground, on which red lines are observed branching, —the blood-vessels,—and a conspicuous circular spot, at first appearing almost wholly white by contrast with the surrounding redness, is noticed,—the *optic papilla.* On closer observation, the several parts assume more definite characters, but some of these are found to vary in different individuals. It is, therefore, useful to study the appearances presented by each structure separately, so that their abnormal conditions may afterwards be more easily appreciated.

In the following description, the ophthalmoscopist is supposed to be making his observations by the indirect method.

The Fundus, by which term is implied the whole of the interior of the retinal sphere which can be brought into view through the pupil, is generally of a pink or orange tint, depending on the reflected rays from the choroid which are seen through the transparent retina. The colour of the fundus varies in men of different shades of complexion. In the negro it can scarcely be illuminated; in the albino it is very pale and bright. This depends upon the amount and disposition of the epithelial pigment.

Optic Disc, or Papilla.—The termination of the optic nerve, or the spot at which it expands into the retina, is usually of a light pink tint, but sometimes appears as if a light grey were mixed wtih the rose colour; and this light tint, and its defined outline, distinguish it at once from the rest of the fundus whatever the degree of colour may be. It is nearly circular in form, occasionally longer in the vertical than in the horizontal diameter: but if the horizontal axis be the longer, the condition usually indicates disease. The centre of the optic disc which appears bright and white is slightly depressed, and is surrounded by what appears as a somewhat elevated rounded zone. This zone is called the *colliculus.* It has the appearance of a shaded ring, and is often more shaded on one side than on the opposite side. The deeper shading may depend on the thickness of the retinal fibres, or on some effect of the light thrown upon its rounded surface. Immediately outside the *colliculus* is the light pink limit of the optic disc. This is bounded by a fine whitish ring indicating the *scleral aperture* or inner sheath of the optic nerve joining the sclerotic tunic. Sometimes there is a complete linear circle, sometimes a narrow crescent on one side, of a black colour, pointing out the choroidal limit. When a complete ring is visible, the appearance is due to encroachment of the choroid upon the sclerotic aperture; when crescentic, it is owing to the peculiar direction in which the optic nerve enters, passing more obliquely than usual, so as to leave a slight edge of the choroidal opening exposed to view. The apparent size of the optic disc varies according to the refractive qualities of the eye under observation, as well as on the differences of the lenses through which it is observed. The observer must be prepared to meet with many varieties in shade of colour, outline, and appearance of the optic disc even in normal eyes.

Central Artery of the Retina.—This vessel does not always appear central in reference to the optic disc, but sometimes just shows itself halfway between its centre and circumference. It often remains single for some little distance after emerging from the disc, and then divides into an upward and downward branch. These branches are seen to divide dichotomously, ramifying in all directions, toward the periphery of the retina. They arch around, not over, the situation of the macula lutea.

Venous Circulation of the Retina.—The two principal venous branches usually join to form the central vein of the retina deeper in the optic nerve than the division of the artery. The venous ramifications correspond in their directions with those of the arteries; they are, however, readily distinguished from each other. The arteries may be known from the veins by their smaller calibre, lighter colour, sharper outline, and more marked evidence of their tubular formation. The thinner coats of the veins cause their contents to be more readily seen, and hence their darker and more red appearance. They are not seen with the same distinctness in all directions even when allowance is made for difference of size; because, in some parts they are lying immediately beneath the *membrana limitans,* while in others they are covered in addition by the expansion of the optic nerve and are lying in the layer of the retina beneath. This becomes more noticeable when the transparency of the retina is lessened by any cause.

Lamina Cribrosa.—Sometimes part of the optic nerve may be seen to be studied with minute grey spots. These are the openings of the *lamina cribrosa.* The obliquity with which the nerve fibres enter the fundus to expand into the retina causes the margins of these openings to become visible.

Retina.—The retina is so transparent as not to be itself visible: it is recognized by means of the vessels which ramify in its texture. When the choroidal pigment is very abundant, and the fundus, therefore, deeply tinged, the retina may be sometimes noticed by its reflecting the light in such a manner as to give the resemblance of a faint bluish haze over parts of its surface. The retina is more transparent towards its periphery, because the fibrous lamina is less thick as it retires further from the optic disc.

Macula Lutea.—This part of the fundus is not easily discernible until after some practice with the ophthalmoscope. But its position may be readily found from being in the direct axis of the eye. It appears as a nearly round spot of a darker shade of colour than the rest of the fundus. The appearance of a yellow halo, *limbus luteus,* such as is described in cadaveric examinations of the eye, does not present itself under ophthalmoscopic illumination. Branches of the retinal artery of second size arch above and below, but do not cross it, and its immediate neighbourhood usually appears free from even the smallest vessels. In the centre of the *macula lutea* is a minute white spot, sometimes appearing like a very small white ring with a dark point in its centre. This is the *fovea centralis,* formerly wrongly designated the *foramen centrale.* The shade of the *macula lutea* is darkest immediately around the *fovea centralis.*

Choroid tunic.—The choroid is recognized chiefly by its vessels and pigmentation. The choroidal vessels, though larger than the retinal vessels, are not ordinarily seen. They are more or less visible according to the varying amount of pigment in the epithelial stratum, intervening between them and the retina. Sometimes the interspaces of the choroidal vessels, from the stroma of the vascular layers containing abundant pigment, show themselves through the retina like dark patches and stripes, the vessels appearing among them like a bright red net-work. The fundus has then the appearance of being streaked like the skin of a tiger. In light-complexioned persons, in whom a comparatively small amount of pigmentation exists both in the pigmentary epithelial layer, and in the cells of the stroma of the vascular layers, the finest ramifications of. the choroidal vessels are sometimes traceable by the ophthalmoscope. The less pigment there is in the choroid, the more reflection there is from the sclerotic coat, and the lighter is the pink or orange colour which the fundus assumes. Thus the colour and appearance of the fundus is constantly diversified by differences in the amount of pigment in the epithelial layer, and in the stroma of the vascular layers of the choroid.

Humours of the Eye.—These, in the normal eye, are not seen, or, in other words, are perfectly transparent when the eye is examined ophthalmoscopically.

CHAPTER III.

Ophthalmoscopic Appearances, and Diagnostic Signs, of Morbid Conditions of the Structures within the Ocular Cavity.*—Importance of Accuracy of Diagnosis in the Military Service.—Ophthalmoscopic Diagnosis of the Myopic and Hypermetropic Anomalies of Refractive Power.—Lesions of the Optic Nerve and Retina.—Anæmia.—Atrophy.—Depression or Cupping.—Hyperæmia.—Inflammation of the Optic Nerve.—Retinitis.—Retinal Hæmorrhage.—Detachment of Retina.—Retinitis Syphilitica.—Retinitis Albuminuriensis.—Lesions of the Choroid.—Hyperæmia.—Choroiditis Disseminata.—Retino-Choroiditis.—Chorio-Retinitis Pigmentosa.—Posterior Staphyloma.—Morbid Changes in the Dioptric Media.—Cysticerci in the Ocular Cavity.—Impaired Vision from Wounds near the Orbit without direct Injury to the Eye.

It will be convenient, in recording succinctly the diagnostic marks of the several diseases which are capable of being recognized by the ophthalmoscope, to follow the order which was adopted in the preceding chapter for describing the normal appearances of the several structures visible in the interior of the globe of the eye.

The term "amaurosis," which never, indeed, conveyed much definite information, is scarcely any longer admissible in scientific records. Under any circumstances it should only be applied to those disorders of vision in which the seat of impairment is external to the globe, and due to lesions of the optic tract, or the cerebral origin of the nerve.

The study of ophthalmoscopic *diagnosis* is especially of importance to medical officers. It is not often that the medical officer is called upon to subject to prolonged treatment patients labouring under impaired vision depending upon deep-seated lesions, when the disease has become so advanced as to render the diagnostic marks plainly manifest. If the disease be discovered in a recruit, the man is simply rejected as unfit for military service. If the diagnosis be established unmistakeably in a soldier already in the service, he is invalided and discharged from the army. And, remembering how rarely a cure can be hoped for from any treatment in such advanced cases, it would evidently be unjust to the public service to retain in the ranks of the army a soldier who is so little likely to become efficient, when once the nature of his disease has been clearly defined. The military surgeon has therefore to turn his attention more to acquiring accuracy of diagnosis than to experimenting upon the effects of remedies in lesions of the tunics within the cavity of the eye. But a further advantage of the study of ophthalmoscopic diagnosis is that it may lead to these diseases being distinguished in earlier stages than they are usually recognized at present, when treatment may be of essential use in arresting their progress.

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* It is, of course, essential that the surgeon should be well acquainted with the textural anatomy of the parts concerned in vision, in order properly to appreciate the appearances which accompany many of the lesions rendered visible by the ophthalmoscope, and the phenomena which accompany them. A minute and lucid description of the histology of the tunics and refractive media of the eye will be found in the last edition of Quain's Anatomy, by Sharpey and Ellis, vol. 3., pages 1 to 35.

Before proceeding to describe the indications of structural lesions, it will be useful first to notice the applicability of ophthalmoscopic examination to the detection of deranged refractive power in the eye, whether the defect be *myopia* or *hypermetropia.* It may occasionally happen that the surgeon is unable to arrive at a certain conclusion in reference to the existence of these sources of impairment of vision, from the stupidity of the patient or from determination on his part to try and thwart the surgeon's object. In such cases the ophthalmoscope can be resorted to with great advantage, and, if the impairment of vision be at all severe, its presence and its nature can be readily detected. The test-types or test-dots will show the degree of alleged disability, and as, if any, a high degree of the malady, is likely to be assumed, the following mode of observation will determine the question, without the subject having any power to interfere with the conclusion.

Diagnosis of Myopia.—When explaining the various methods of using the ophthalmoscope, two direct methods were described. The second of these, in which the eye of the observer was placed from 16″ to 20″ from the eye under examination, was said to be rarely resorted to on account of the indistinctness of the aerial image formed in front of an emmetropic eye. But if, instead of being emmetropic, the examined eye be myopic, then, on the focal distance being reached, a very distinct image is found to be formed by this direct method. The image is reversed. It is recognized as such by the fact that if the observer's eye be fixed on some small object in the fundus, as one of the retinal vessels, and he then moves his head to one side, the vessel will appear to move to the opposite side. The explanation of this effect is easily understood, if it be remembered that the only *entering* rays which the myopic eye can focus are divergent rays, and that for the same reason the rays *passing out* of the myopic eye are convergent rays. The convergency causes the rays to meet at a point of intersection a few inches in front of the eye, and then to become divergent; so that the examiner, by placing himself at a proper distance, is able to bring the rays which diverge on leaving the point of intersection to a focus upon his retina, and there to obtain an image, necessarily reversed, of the object from which the rays proceeded. Now if the subject under examination describes himself to be very shortsighted, the presence of the reversed picture of the fundus on examination by this direct method would prove the correctness of his assertion, and for the same reason its absence would show the man's description to be unfounded, or that it was connected with some other form of disability.

Diagnosis of Hypermetropia.—This anomaly of refraction is detected with the ophthalmoscope by the same direct method of examination. But in this case the image of the fundus is erect, instead of being reversed. The hypermetropic eye, it will be remembered, is adapted to *receive* convergent rays, and therefore the *reflected* rays pass out of the eye divergently. The observer, therefore, has to find the distance at which his eye will bring these divergent rays to a focus, and, on this being found, he immediately perceives a very distinct upright image of the background of the eye under observation. The test, described in the Diagnosis of Myopia as affording the means of recognizing the reversed image, when applied to the object seen in the fundus of the hypermetropic eye, exhibits a contrary result, and thus equally serves to prove that the image in this latter case is erect. If the observer, after fixing his eye upon a retinal vessel, moves his head to one side, the vessel will appear to move in the same direction. This is a necessary consequence of the reflected rays coming direct from the object under observation, and not crossing each other after their exit, as from the myopic eye, and thus a most facile method of diagnosing the hypermetropic condition is afforded.

In the following three Sections the principal morbid conditions to be recognized are shortly described:—

SECTION I.—LESIONS OF THE OPTIC NERVE AND RETINA.

Lesions of the Optic Nerve are of course intimately associated with corresponding lesions of the Retina, and in many instances cannot be observed apart from each other. In some diseased conditions, however, the characteristic signs are so marked in the optic papilla that they attract the surgeon's attention from their special appearances. Such are Anæmia of the Optic Nerve, Atrophy in its several stages, Simple Hyperæmia, and the excavated or depressed condition, which is generally known by the name "Cupping." There are doubtless corresponding changes in its retinal expansion accompanying all these altered appearances of the optic nerve, although from the disposition of the nerve fibres and connective tissues in the latter, and from the transparency and disposition of the vessels in the former structure, the changes are obvious in the one, but not observable in the other. That these changes do exist, though not visible, may be often sufficiently known by their effects on vision.

1. ANÆMIA OF THE OPTIC NERVE.

Ophthalmoscopic Appearances.—The normal rose, or greyish pink, colour of the optic papilla is absent, and, instead, a dull white appearance is presented. The arterial vessels are shrunken, and appear particularly contracted by contrast with the veins, which are often turgid and tortuous. If the anæmia is symptomatic of advancing atrophy, the diameter of the papilla becomes lessened, and the circular aperture of the sclerotic, or scleral ring, becomes more obviously apparent.

Diagnostic Signs.—The paleness of the papilla and the contracted vessels are the principal diagnostic marks. In estimating the degree of anæmia, the general colour of the fundus should be noticed, for the contrast will be increased in proportion to the darkness of the fundus, and the paleness be more striking. The history of the case, the appearances of early ophthalmoscopic observations, if they have been taken, probably limitation of the field of vision as well as of visual power, will assist in establishing the diagnosis, and perhaps elucidate the causes of the affection.

2. ATROPHY OF THE OPTIC NERVE.

Ophthalmoscopic Appearances.—The optic papilla is of a bright, chalk-white aspect, and its limit usually sharply defined. The colourless condition forms a striking contrast with the rest of the fundus, so that it is very easily recognized. The retinal vessels appear less in number than usual. They are thin, and often cannot be traced far from the optic entrance. The atrophied papilla frequently becomes depressed and excavated, and sometimes is attended with a marked greyish spotting indicative of the lamina cribrosa.

Diagnostic Signs.—The peculiar whiteness of the papilla in atrophy prevents it from being mistaken for any other condition. It is frequently associated with intercranial causes, which can only be elucidated by a careful investigation of the history of the case, and study of the symptoms concomitant with the progress of impairment in power of vision. In complete atrophy vision is wholly lost. There is no sensitiveness when the strong light reflected from the mirror is thrown upon the fundus.

3. DEPRESSION OR CUPPING OF THE OPTIC DISC.

Ophthalmoscopic Appearances.—These vary as the depression is general or partial. When general, the attention is attracted to the defined scleral boundary of the papilla and the peculiar disposition of the retinal vessels as they pass from and to its centre. The sclerotic appears like a narrow ring of more or less light yellow colour surrounding the optic foramen. The excavation of the disc at first produces on the eye of the observer the effect of a conical protrusion. This is an optical illusion explained by the fact that light falling with a little obliquity upon a concave surface is reflected from the side opposite to that from which it is reflected when thrown upon a convex surface, and the circumstance of the relative positions of the light and shade being changed in the inverted image. The vessels at the edge of the disc are seen to bend abruptly, and on being observed attentively, indicate the differences in level between the papilla and retina. The surface of the papilla is whiter in the centre than in the surrounding part of its disc, where there is not only a darker shading of greyish pink colour, but also a number of grey spots marking the lamina cribrosa are frequently seen. This appearance of the lamina cribrosa is the more marked as the excavation is deeper. When the disease is advanced and the excavation extends circumferentially, the margin of the sclero-choroidal opening becomes undermined, so that the branches of the retina vessels on reaching it have to curve round and pass under it. They are thus for a short space lost to view, and appear separated from the main divisions of the central artery and vein. The veins which lie upon the optic disc appear to the eye to be shrunken and more pale than the ramifications upon the retina. The retinal arteries appear small and thin, while the retinal veins are distended and often tortuous, as occurs in atrophy. The *vena centralis* on being carefully observed may often be seen to pulsate, an effect due to the state of intra-ocular tension. The same effect may be produced artificially on pressing the upper part of the globe of a normal eye by means of the finger placed upon the eyelid. But under the circumstance of intra-ocular pressure, the vein may be seen spontaneously alternately losing its colour and becoming apparently narrower, and then dilating again and assuming a dark colour from fresh injection of its contents. If the pressure be increased by the finger the same effect will be rendered visible in the artery. It is well, when making this experiment, to fix the eye upon a branch at the spot where it passes over the border of the scleral opening to the surface of the optic disc.

In the other form of cupping the excavation is more gradual, so that the appearance of interruption in the continuity of the vessels is not presented. The vessels, or some of them, according to the extent affected, are seen to form a curve as they reach the schleral margin, but can always be followed to the trunk from which they ramify.

Diagnostic Signs.—The peculiar aspect of the vessels sufficiently establishes the condition of the optic entrance. In the first form, in which the depression abruptly commences at the periphery, the larger veins afford the most marked evidence of the cupping; in the second the smaller vessels, as they can only be seen when close to the surface of the papilla, are the safest guides. The first form is diagnostic of diffused intra-ocular pressure, such as occurs in glaucoma, a condition which is further indicated by the pulsation of the central vessels, and the tense state of the globe perceptible on external pressure; the second points to wasting of the nerve tissue, or that form of atrophy which used to be called "cerebral amaurosis." The amount of change of direction which the vessels lying on the optic papillary surface assume in turning over the scleral margin to ramify on the retina indicate, to a certain extent, the depth of the excavation.

4. SIMPLE HYPERÆMIA OF THE OPTIC NERVE.

Ophthalmoscopic Appearances.—Hyperæmia, which may be due to simple congestion, or to inflammation concurrent with retinitis, shows itself by an exaggerated colouring of the disc. The depth of colour varies according to the amount of hyperæmia, from a rose blush to greyish red; and as the colour increases, the papilla becomes less conspicuous from loss of contrast with the general colour of the fundus. Hyperæmia from simple congestion is seen very frequently in persons who are subjecting their eyes to excessive strain at near objects, especially when an abnormal condition of refractive power is not corrected by suitable lenses. In such cases the pinkiness may be limited in appearance to the *colliculus*, or to a part only of the *papilla*, or the whole disc may appear injected.

Diagnostic Signs.—The appearances described, together with the absence of the indications of serious lesions in the other structures, sufficiently distinguish this condition. The appearances will in many cases be confined to the nerve of one eye.

5. INFLAMMATION OF THE OPTIC NERVE AND RETINITIS.

Ophthalmoscopic Appearances.—In inflammation, the indications of hyperæmia just described are followed by a train of appearances which vary according as inflammatory products are effused, or more remote consequences developed. Inflammation of the optic nerve is necessarily so connected with *retinitis*, that, as already mentioned, they can only be noticed together. When inflammation has supervened, not only is the papilla less conspicuous, owing to its state of injection, but its circumferential limit becomes less defined. This obscurity appears owing to a haze covering the papilla, like, as it were, a veil extending over it, and becoming blended with the surrounding fundus. The optic entrance appears magnified, yet uncertain. Elevation, or intra-ocular projection of the papilla, has also been noticed as an accompaniment of inflammation. The arteries of the retina are lessened in calibre, the veins appear greatly increased and frequently tortuous. The vessels cannot be followed to their regular termination in the two central arterial and venous trunks, but seem to finish rather abruptly at several points upon the surface of the papilla, at varying distances between its circumference and centre. All these appearances appear to be chiefly due to exudation or other products arising from the inflammatory action. Variations in the appearances presented continue according to the course the inflammatory action pursues. It may proceed to resolution, and partial recovery, to atrophy, to extension of the inflammatory action to other structures, or, in its chronic form, induce a variety of consequences, some of which will be noticed hereafter.

Diagnostic Signs.—If the inflammation of the nerve and its expansion be acute, there will be very great intolerance of ophthalmoscopic examination, and even in its sub-acute or chronic forms, retinal inflammation is at once indicated by the photophobia which is manifested on lighting up the back-ground of the eye. The marked sensitiveness on exposure to light, together with great impairment of the normal visual power; frequently photopsia, or the appearance of bright luminous spots moving before the eye, indicating a congested condition of the capillary vessels of its back-ground; combined with the ophthalmoscopic appearances, serve to diagnose the disorder.

6. Retinal Hæmorrhage.

Ophthalmoscopic Appearances.—Sub-retinal extravasations of blood, which may result from any cause inducing excessive vascular congestion, present appearances which can scarcely be mistaken under ophthalmoscopic examination. The spots present the usual colour and characters of ecchymoses in other parts. The extravasation may be limited to one spot, probably in the immediate neighbourhood of a bloodvessel, or may be scattered in irregular patches over the fundus. Some of the vessels will probably appear pale, as if emptied of their contents, or are lost to view altogether. Under continued ophthalmoscopic observation, the ecchymosis may be seen gradually to diminish in size and darkness of colour, if the structures be originally healthy and favourable absorption of the effused blood takes place, vision being gradually restored as these changes occur; or it may be succeeded by the usual indications of choroidal atrophy, detachment of the retina, and other results.

Diagnostic Signs.—The ophthalmoscopic appearances sufficiently establish the nature of the disorder. The history of the case, perhaps sudden complete loss of sight, or obscuration of part of the normal field of vision, will always aid the diagnosis. If the hæmorrhage has concurred with some structural degeneration, as occurs in albuminaria or in syphilitic changes, the previous amblyopia will have sufficiently pointed to this predisposing condition.

7. Detachment of the Retina.

Ophthalmoscopic Appearances.—As just noticed, after retinal hæmorrhage, or if retinitis be followed by serous exudation, or if from any cause, such as accidental blows about the orbit, or vascular distension, an effusion of blood takes place from the choroid, and lodges between it and the retina: the occurrence is often followed by separation of the retina to a greater or less extent. This condition is recognized by the following appearances. The ophthalmoscopic observations may be made by the direct or indirect method. If the direct method be employed, and the fundus be observed after the patient has turned the eye two or three times quickly upwards and downwards, a fold of an opaque white or bluish gray colour may be noticed having a slightly undulating movement. If it be then observed with the aid of the object lens, not only the wavy fold will be seen, but small vessels may be noticed upon it, and these will alter in size, direction, and focal distance, in correspondence with the movements of the retinal fold. If the detachment be of long standing, the waving movement and the retinal fold itself will be more conspicuous, probably from the retina being looser as well as from its being more opaque, and therefore reflecting more light to the eye. When it is recent, the colour of the effused fluid beneath is more obvious; if this be transparent, the red fundus will be seen through it, excepting in lines where the retina happens to be folded upon itself. Such detachments are usually partial, and therefore the appearances may only be noticeable in certain positions of the observed eye; if it happen to be detached from the whole circuit of the optic disc, the disc will generally be hidden by its movements. The movements of the detached retina can sometimes be observed with the aid of favourable position and a good light without the ophthalmoscope.

Diagnostic Signs.—The movements of the small vessels agreeing with the movements of the fold, serve to diagnose this lesion. The general indications will vary with the extent and site of the detachment. If the retina around the macula lutea be undisturbed, partial vision will be retained. The patient complains that his vision is impaired by the presence of a dark cloud before the eye: or perhaps he labours under hemiopia, the upper half of the field of vision being that which is usually lost. If the detachment be limited, the effused fluid may become absorbed, and vision become again better.

8. RETINITIS SYPHILITICA.

Ophthalmoscopic Appearances.—The impairment of vision which is occasionally found to accompany certain constitutional pathological conditions, such as syphilis, morbus brightii, &c., without any appreciable changes in the external structures of the eye, has been shown by ophthalmoscopic observation to be accompanied by characteristic changes in the aspect of the retina. The syphilitic retinitis is characterized by cloudiness of the optic disc, haziness of the retina, which is extensively diffused, and by scattered spots of retinal ecchymosis. The bluish white retinal haziness is most marked around the optic entrance, along the course of the principal vessels, and around the *macula lutea,* but it has no where any defined limits. A number of minute light spots are occasionally irregularly disposed around the *macula lutea.* The syphilitic retinitis is also not unfrequently accompanied by disseminate spots of choroidal atrophy.

Diagnostic Signs.—The ophthalmoscopic appearances, together with the syphilitic history, sufficiently establish the diagnosis. Under judicious treatment, such as would remove the syphilitic taint expressed in other parts of the frame, the retinitis may disappear, the ecchymosis be absorbed, and the impaired vision greatly restored. A certain amount of amblyopia will always remain.

9. RETINITIS ALBUMINURIENSIS.

Ophthalmoscopic Appearances.—The optic disc is indistinctly seen as if through a haze, and altogether offers the appearance it has been described to assume in the remarks on simple retinitis. It appears blended with the surrounding retina, which is opaque for some distance around, but not of an uniform colour. Around the papilla it is ordinarily of a yellow colour inclining to brown, and this passes into a diffused dead white border, of irregular outline, at the outer margin of which are scattered a large number of separate white spots. The outline of the white opacity, with its border of white spots, is rather sharply defined, so that the whole diseased appearance is isolated as it were from the rest of the fundus so far as colour is concerned. A group, or circle of similar white spots, is disposed around the macula lutea. These appearances are described to be partly due to serous infiltration and increase of the connective tissue, and partly to fatty degeneration, particularly affecting the anterior extremities of the radial fibres of the retina. The arteries are finer, while the veins are more distended and tortuous, than normal. Hæmorrhagic spots, both retinal and sub-retinal, are scattered over the fundus, as well in the altered part of the retina as in other parts where no visible change has occurred. While the disease is advancing in its earlier stage the white spots coalesce, and thus extend the limits of the white margin, but subsequently the serous infiltration may in great measure disappear, and the disorder terminate in complete atrophy.

Diagnostic Signs.—The locality in which the appearances above described show themselves, the manner in which the infiltration or fatty patches are disposed around the clouded entrance-disc, the spots round the *macula lutea,* combined with the hæmorrhagic appearances, are said to be absolutely sufficient to characterize them as connected with Bright's disease. The amblyopia resulting from the retinal changes is usually not noticed until the disorder is in an advanced stage.

SECTION II.—LESIONS OF THE CHOROID.

The choroid tunic is the seat of a variety of lesions which are exceedingly conspicuous under ophthalmoscopic observation, from the contrasts in colour which are presented when exudation, or atrophy of its structure, has taken place, and the epithelial layer of pigment cells has been disturbed. From its great vascularity it is frequently the subject of simple congestion, or inflammation, leading to some of the changes above noted. It is also the frequent cause of associated or consecutive disease in the retina.

These morbid conditions of the choroid, or choroid and retina, are chiefly recognized under the forms of "choroiditis disseminata," "retino-choriditis," and "chorio-retinitis pigmentosa."

1. Congestion of the Choroid.

Ophthalmoscopic Appearances.—The differences in the colour of the choroid in its *normal* condition, already noticed, render considerable practice necessary for forming a correct judgment of the appearances which are presented under simple congestion or hyperæmia. Congestion will cause an increased depth of red colour in the fundus, but in order to recognize the amount of increase, the complexion of the individual must be considered, and the manner and extent to which the redness is distributed. If the congestion be limited to one eye, there will be a contrast of colour between it and its fellow. If the complexion be light, and the epithelial layer be not rich in pigment, the choroidal veins will be probably perceived to be fuller than normal, and perhaps tortuous.

Diagnostic Signs.—In addition to the increased redness of the fundus, the general symptoms of choroidal congestion must be looked for to aid in establishing the diagnosis. These are—a sense of tension in the globe, and speedy fatigue on application of the eye to near objects as in reading; *scotomata* or *muscæ volitantes*, and *mistiness* of vision, varying in degree from time to time; slight *photophobia* and *epiphora*; and probably frontal headache.

2. Choroiditis Disseminata.

Ophthalmoscopic Appearances.—In this form of choroiditis numerous spots of exuded lymph are seen scattered over the fundus in different directions, usually presenting a strongly marked white, but sometimes a yellow colour. These spots are generally surrounded at their margins by small deposits of very dark black pigment; or the deposits of pigment are grouped at points in their neighbourhood. The exudations may be placed between the choroid and retina, or may be poured out in the choroidal tissue itself. They vary in form and size, but generally appear as small spots, quite separate from each other, more or less circular in outline, and disseminated in groups. Sometimes a layer of exudation appears as if spread out by pressure, and its outline is then very irregular. The pigment at the margin has the appearance of having been removed from the part where the exudation has taken place, and of being heaped together in patches where the deep black colour appears. These black spots are said to be enlarged epithelial cells filled with a darker pigment than normal. Occasionally little spots of pigment will appear separate from the white exudations. The fundus will sometimes appear hazy in the earlier stage of the disease, but is clearer as it becomes chronic. The vessels of the retina may be observed to follow their course irrespective of the changes just described. They are seen to cross both the white spots, and thin dark margins, or to ramify over the distinct white patches if they happen to be at a part of the fundus where the larger branches of the vessels circulate. The direction of the retinal vessels will sometimes indicate whether the retina has been raised or not by the choroidal exudations beneath. The exudations, if slight, may sometimes be observed to gradually wear away, leaving the choroid complete, though altered and impaired; but usually as they disappear, they leave behind an atrophic condition of its tissues.

Diagnostic Signs.—The ophthalmoscopic appearances described sufficiently distinguish the disease. In addition to the general signs described under choroidal hyperæmia, there will be more or less disturbance and loss of vision according to the site and extent of the exudations.

3. RETINO-CHOROIDITIS.

Ophthalmoscopic Appearances.—If inflammation of the retina be added to that of the choroid, there will be after a time, in addition to the disseminate indications just explained, the misty indistinct optic entrance, retinal exudations, either serous or plastic, and the general appearances described under retinitis. As the active symptoms subside, the appearances and general signs may point to advancing atrophy, or the vision may improve to some extent, but remain permanently weak. In the latter case the ophthalmoscope will probably reveal from time to time improvement in the condition of the retina, but the disturbance of the choroidal structure, especially of its epithelial layer will be found to be permanent. The extent to which vision is affected will frequently be found to depend upon the side where the morbid changes have been chiefly developed.

Diagnostic Signs.—Very marked amblyopia will accompany retino-choroiditis, when severe or advanced in its character, but in the early stages in which the retina has not yet become much implicated in the inflammation, the ophthalmoscopic diagnosis is uncertain on account of the difficulty in appreciating simple inflammatory congestion of the choroidal vessels. When the choroiditis has led to disturbed distribution of the pigment cells, and the other signs noticed under "Choroiditis disseminata," and these are accompanied by opacity of the retina, diffused haze about the optic entrance, or indications of commencing atrophy, the diagnostic signs are clear enough.

4. CHORIO-RETINITIS PIGMENTOSA.

Ophthalmoscopic Appearances.—The most striking ophthalmoscopic appearance is that from which this disease has derived its name, the peculiar manner in which pigment is seen to be scattered over the retina. The immediate neighbourhood of the optic entrance and *macula lutea* is usually free from the pigmentation which appears to be scattered around the periphery of the fundus. The ophthalmoscopic observations are said to have shown that the disease often commences at an early age, and that the pigmentation then advances gradually from the neighbourhood of the *ora serrata* toward the axis of vision, the field of view gradually contracting in proportion. Sometimes the vessels of the choroid are plainly visible in isolated parts of the fundus, proving that the pigment cells of the epithelial layer are in these parts lessened in number. The retinal vessels, which are small in calibre, are hidden by the pigment when their course happens to lie through any of the pigment spots. Sometimes the pigment spots appear to follow the course of direction of the finer ramifications, having a tendency to group themselves within the angles formed by their bifurcations. In these instances the black spots assume the appearance of minute arrow heads, one line of the arrow head lying close to one side of the bifurcation the other line to the opposite side, and both meeting at the point of the angle. The connective tissue around the retinal vessels is said to make it more easy for the pigment cells to group themselves in these directions. In advanced cases the optic entrance as well as the retinal vessels show the usual marks of atrophy.

Diagnostic Signs.—The situation and the character of the pigmentation, together with the condition of the retina, serve to distinguish this disease from choroiditis disseminata. The slow progress of the disease, the gradual contraction of the field of vision, which may be tolerably strong in central fixation, are usually also diagnostic indications.

5. POSTERIOR STAPHYLOMA.

Ophthalmoscopic Appearances.—This disease takes its name from the projection at the back part of the globe of the eye which accompanies it. It used to be generally described under the name of "Sclerotico-choroiditis Posterior," but as the appearances presented are now considered to be the result of changes which are chiefly induced by pressure from increase in the volume of the vitreous humour, of uncertain origin, and not to inflammatory action, this term seems to be no longer admissible. "Ectasia bulbi," or aneurism-like extension of the globe, is another name applied to this disease. It presents a very marked appearance to the observer when examined ophthalmoscopically. Its chief feature is the striking contrast which is presented between the projecting part of the fundus near the optic entrance, and the normal colours of the neighbouring tissues.

In its early stage the disease appears as a narrow white crescent adjoining the optic nerve, being usually placed on its outer side, with the convexity turned in direction towards the *macula lutea.* Its bright whiteness, which is due to the tendinous sclerotic being visible through the wasted choroid, prevents it from being confounded with the optic nerve itself, the limit of which is usually plainly marked. The boundary also between the convex margin of the crescent and the red fundus is strongly defined. A line of dark pigment, or some irregularly shaped patches of pigment, frequently appear around the outer border of the crescent. As the disease advances the crescent extends, as well by embracing the optic nerve more completely within its horns as by spreading from its convex border towards the *macula lutea.* It frequently thus obtains a fan shape, the broad part of the fan expanding towards the outer part of the eye (the apparent inner aspect when seen in the inverted image). Occasionally the aspect presented is a large white circle surrounding the optic entrance, spreading out irregularly in several directions. The whiteness is excessively brilliant, and, as the retinal vessels cross over it, their outline and colour are very strikingly conspicuous. Not unfrequently small isolated patches of choroidal atrophy may be observed in parts of the fundus around, accompanied by irregular groupings of dark pigmentary epithelium. The optic entrance sometimes appears as if it were oval, with its long axis placed vertically, and the vessels appear to proceed from it on one side instead of from the centre; this effect is produced by the peculiar direction in which it is regarded by the observer when the posterior projection is deep. This disease is frequently accompanied by changes of the *macula lutea,* whether atrophic, or seen as small spots of disseminate choroiditis surrounding it. Changes in the vitreous humour and retinal detachment are not unfrequent concomitants also in the advanced stage of the disease.

Diagnostic Signs.—The ophthalmoscopic appearances are characteristic; at the same time, the myopia, which is necessarily induced, corresponding with the extent to which the axis of the eye is elongated by the staphyloma, and amblyopia, are additional aids to the diagnosis.

SECTION III.—OTHER MORBID STATES.

1. GLAUCOMA.

Ophthalmoscopic Appearances.—The ophthalmoscopic appearances in this disease, which consists essentially of changes dependent upon intraocular pressure and consequent excessive tension of the outer tunics of the globe, vary according to the stage of its development. Its prominent features under ophthalmoscopic examination are the peculiar signs of excavation, or *cupping,* of the optic disc, with pulsation of the *arteria centralis* already described, together with congestion of the retina and choroid. The increase in the vitreous humour, from which the intraocular pressure appears to be mainly derived, is not at first accompanied with changes obvious to ophthalmoscopic observation; but, as the disease advances, loss of transparency of the vitreous humour becomes marked. Sometimes this change is shown by a degree of haziness or greyish cloudiness in the humour, proportionably obscuring the view of the fundus. At other times it will offer a yellow tinge, and this colour usually indicates light reflected from extravasation of blood in the retina. The green tinge which is sometimes observed appears to depend on a change in the crystalline lens, and this advances in certain instances to complete cataractous opacity. The usual signs of retinal and choroidal congestion are presented.

Diagnostic Signs.—The ophthalmoscopic diagnosis of glaucoma is much assisted by attention to the subjective symptoms. The abnormal hardness of the globe on pressure by the finger, flattening and dullness of the cornea, dilated pupil, the pain around the orbit, concur with the ophthalmoscopic indications of depression of the optic disc, and of the obstruction to the venous circulation in the retina and choroid, in pointing to the existence of intraocular pressure. It is for the relief of this distension that the operation of iridectomy is now practised. The optical signs are, at first symptoms resembling those of presbyopia, these being induced by the flattening of the cornea, gradual narrowing of the limits of the field of vision and increasing amblyopia, and finally, if the disease advance, complete blindness. The diagnosis between the excavation of the optic disc due to glaucoma, and the depression which is induced by atrophic changes in the nerve, have been already referred to in page 56.

2. Morbid Changes in the Dioptric Media.

Ophthalmoscopic Appearances.—Loss of transparency in the dioptric media, opacities in or upon the cornea, lens, and vitreous humour, are at once noticed when the eye is illumined and examined by the ophthalmoscope. Lateral illumination is preferable for observing the anterior media of the eye as far as the crystalline lens and its capsule, and direct ophthalmoscopic examination for observation of the vitreous humour. The evidence afforded by lateral illumination posterior to the crystalline lens is so uncertain as to be seldom useful in diagnosis. General loss of transparency in either of the media leads to the same effect when the ophthalmoscope is used, viz., an absence of brightness in the fundus, and indistinctness of the objects upon it, in proportion to the degree in which the normal transparency of the media has been lost. But special opacities are conspicuous as dark objects in the field of view, and it is frequently desirable to determine in which of the media these dark objects are contained. There is no difficulty in establishing the diagnosis when they are upon the cornea, whether superficial or interstitial, for if the naked eye cannot perceive them, their position and limits can be easily ascertained by lateral illumination. Lateral illumination will also exhibit plainly, after dilatation of the pupil, opacities of the crystalline lens, whether situated upon the anterior or posterior aspects of the capsule, or in the structure of the true lens. One advantage of checking the ophthalmoscopic appearances by lateral illumination is that the colours of the opaque objects are seen by it, whereas by the ophthalmoscopic illumination they always appear in shade Thus the white bands of lymph after iritis, or spots of the uveal pigment, upon the front of the lens are seen in their natural colours by the one mode; by the other they both appear equally black colourless objects. In making these observations, a bright light is better for the oblique lateral illumination, a weak light for ophthalmoscopic examination. If a strong light be used in the latter method, and the corneal or capsular opacities happen to be very thin, or the lenticular cataract be in a very early stage, these causes of cloudiness in the vision of the patient may be overlooked by the examiner from the reflected rays passing through them; and no shadow existing to render them visible. With a weak light under ophthalmoscopic observation, the most delicate of the lines or radiating striæ which occasionally occur in the substance of the lens in the earlier stages of certain forms of cataract will be rendered plainly visible as fine dark streaks, more plainly than they will be by lateral illumination.

Opacities in the vitreous humour when small and not very numerous, are generally not so readily conspicuous, but require a little management, in order to bring them distinctly under notice. They also should be observed by the direct mode, and with a moderate degree of light. The patient should be told to move his eye quickly in opposite directions two or three times, then to look straight at the sight hole of the mirror. In this way small opacities may be observed to float past the fundus in various directions, and to settle down slowly toward the lower part of the field exposed to view. Their manner of movement, and varying forms, readily distinguish them from opacities whether of the cornea or crystalline lens, which possess definite outlines, and retain fixed positions. An effusion of blood in the vitreous body will be usually found at its lower part. It will appear as a dark irregularly shaped object, with surrounding haziness, projected against the illumined fundus. If, in addition to floating opacities in the vitreous humour, there exists softening of its structure (synchysis), the opacities are usually seen more readily, because they are more easily put into movement; but the chief means of forming the diagnosis, so far as the synchysis is concerned, will be the peculiar undulating movement of the iris, to which the name of "tremulous iris" is given, as well as the other symptoms usually indicative of pathological changes in the globe of the eye.

3. CYSTICERCI IN THE OCULAR CAVITY.

Several instances in which the presence of a cysticercus, either in the vitreous humour or beneath the retina, has led to impairment of vision and curtailment of the visual field, have been observed by the ophthalmoscope and fully recorded. Great care will be necessary to establish a diagnosis in these cases. When beneath the retina, the animal has appeared as a bluish semitransparent vesicle, and some of the usual vessels have been seen to ramify upon the projecting retina. The head and neck have been indistinctly traced through the vesicle, and movements have been observed. It would seem that when these entozoa have been noticed in the vitreous humour they have previously existed beneath the retina, and have made their way from that situation into the latter by a gradual advancing movement. In the vitreous humour the form of the head and neck, its attachment to its vesicle, and the movements of the animal, have been very plainly distinguished by ophthalmoscopic observation, and it has even been extracted with success by Dr. Liebreich. The presence of the cysticercus leads to opacities in the surrounding vitreous humour, which Dr. Liebreich has attributed to the effects of suction, that being the manner in which the nutrition of the animal is carried on. They may also be due to inflammation excited by the presence of the parasite. The ocular cysticerci have in some cases been associated with the presence of tapeworm, in others with indications of cystic entozoa in other parts of the body: the history of any suspected case of this disease should be inquired into in this respect, with a view to additional elucidation of the indications necessary for forming an accurate diagnosis.

4. Loss or Impairment of Vision from Blows upon the Bones of the Orbit, or in their Neighbourhood.

It frequently happens that gun-shot wounds of the face or forehead are followed by irregularity, impairment in power, or total loss of vision, without direct impingement of the eye itself, or any evidence of injury, so far as its anterior structures, which are exposed to view, are concerned. Blows accompanied with less violence, such as a stroke from a stone, from the jerk of a horse's head against the edge of one of the orbits of its rider, and other injuries, sometimes apparently trivial in their nature, will occasionally produce the same effect. Before the use of the ophthalmoscope, these accidents were generally attributed to concussion of the optic nerve, but they are now known to be owing to lesions which are usually rendered obvious enough by ophthalmoscopic examination. Either the retina wholly or in part is found to be detached: or there is effusion of blood beneath it, or in the vitreous body: or the retina is found to be rent across: or isolated fissures occur in the choroid: or inflammatory action is set up in the retina and choroid, which eventually leads to retinal thickening, atrophy, or complete disorganization. The ophthalmoscopic appearances of these several conditions, which have been already noticed, will of course vary according to the length of time which has elapsed between the injury and the date of observation. Intra-orbital hæmorrhage, and pressure upon the globe, may lead to diplopia and other lesions, more or less temporary in character. In old cases complete atrophy of the optic nerve will be sometimes found; sometimes the scar, where the retina, or choroid, has been torn, will be apparent as an opaque white or yellowish line in some part of the fundus: sometimes the usual evidences of retino-choroiditis will present themselves: and in other cases the vitreous humour will be found to have undergone changes consequent upon irritation set up by the presence of the previously existing clot. In such instances ophthalmoscopic examination is often the only means of proving positively that a soldier is not simulating the defect of sight of which he complains.

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